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AN INTRODUCTORY STUDY OF THE PSAMMOCHARINÆ WITH SPECIAL REFERENCE TO THE AMERICAN SPECIES OF THE GENUS LOPHOPOMPILUS RADOSZKOWSKI.*

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INTRODUCTION.

Some years ago, while a postgraduate student at the Massachusetts Agricultural College, the writer undertook the systematic study of the Psammocharid (Pompilid) digger wasps of the subfamily Psammocharinæ. Through the kindness of many persons, who loaned material from various museums and private collections, several thousand specimens were thus made available for this study. This material consisted of species taken over a wide geographical range, including Alaska, various parts of Canada, the greater part of the United States, Mexico, the West Indies, Central and South America, and in addition many specimens from the Australian, Palearctic and Oriental faunal realms. The writer has also examined most of the type specimens of American species belonging to this subfamily in the various collections both in this country and abroad. These types included those of E. T. Cresson, Sr., Fox, Vierick, Robertson, Banks, Frederick Smith, Cameron and others. Owing to the inadequacy of the original descriptions, it is felt that very little could have been accomplished with this group had not the examination of these types been possible. It was

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hoped to have published much earlier but the pressure of teaching duties and economic problems has made this impossible.

Establishment of the Genus Lophopompilus and Synonomy.

In 1887 General O. Radoszkowski established Lophopompilus as a subgenus of Pompilus (Horæ Societatis Entomologicæ Rossicæ, XXI, 1887, p. 42). Radoszkowski designated no type but included under Lophopompilus, in order, the species *grandis* Eversm., *przewalskii* Rad. and *zelleri* Dahlb. This writer, in the publication cited, also figured the male genitalia and referred to the plumose or tufted genital cover ("couvercle genital panache"), a character which clearly distinguishes the males of this genus from those of all other genera of the subfamily. This reference to the plumose genital cover really applies to a sagittate plate attached to and overlying the base of the subgenital plate like a keel. It appears merely as a rather inconspicuous hirsute piece projecting from under the emargination of the penultimate ventral abdominal segment. (Plate XII, Figs. 1, 2 and 4). In 1902 Ashmead erected the genus Pompilogastra, designating *Pompilus æthiops* Cress. as the genotype (Can. Ent. XXXIV, 1902, p. 81). *P. æthiops* Cress. is certainly congeneric with the species placed in Lophopompilus by Radoszkowski. Pompilozastra Ashm. therefore, becomes a synonym of Lophopompilus. In the publication just referred to (p. 84) Ashmead designates *Pompilus grandis* Eversm. as the type of Lophopompilus. *Pompilus grandis*, accordingly, becomes the genotype, or "type by subsequent designation."

Banks (Journ. N. Y. Ent. Soc. XIX, 1911, p. 221) intimated the possibility of synonomy between Pompilogastra and Lophopompilus. He evidently became confirmed in this opinion later as he correctly discards Pompilogastra for Lophopompilus, for *æthiops* and related species. (Bull. Museum of Comparative Zoology of Harvard College, Vol. LXI, 1917, p. 108).

American Species Assignable to the Genus Lophopompilus.

Only four American species can be definitely assigned to the genus Lophopompilus. These species are *atrox* (Dahlb.), *bengtssoni* n. sp., *æthiops* (Cress.) and *cleora* (Banks), all North

American species. No South American species of the genus are as yet known. The species *bengtssoni*, possibly on account of its similar size, color and distribution, has not previously been separated from *atrox*. Both the male genitalia and external morphological characters, however, show these two species to be distinct. *Pompilus ephippiger* Sm. and *Lophopompilus carolinus* Banks, the types of which have been examined by the writer, may possibly belong to this genus, but as there are only two female specimens of the former species and one female of the latter, assignment to this genus at the present time would be purely guess work. Although a great deal of material has been examined, no males have ever been seen which might possibly be those of either of these two species, possessing at the same time the generic characters of Lophopompilus. *L. ilione* Banks is a synonym of *L. æthiops* (Cress.) and *L. autilione* Banks, described from a male specimen and assigned to this genus by the author, is apparently a male of *P. bellicosus* Banks. It does not possess the plumose subgenital plate and therefore does not belong to the genus Lophopompilus. The type specimens of both *ilione* and *autilione* have been examined.

Characters of the Genus Lophopompilus (Pompilogastra Ashm.).

Type: *Pompilus grandis* Eversmann, *Pompilus samariensis* Pall.(?).

Radoszkowski (Horæ Soc. Ent. Ross. XXI, 1887, p. 42) gives the characters of Lophopompilus as—all the characters of Pompilus except that the clypeus is emarginate and the genital cover plumose (translation). This tufted or plumose "genital cover" occurs only in the males and is found in no other genus known to the writer. The emargination of the clypeus in the females is very distinct but does not occur at all in the males. It should be noted that the character of the emarginate clypeus is possessed also by the females of certain other genera. The posterior margin of the pronotum in both sexes is broadly arcuate. Unfortunately the venation is of such a variable character that it can hardly be said to exhibit any distinctive generic peculiarities. The color for the members of this genus shows almost no variation from one of two types for both American and exotic species. It is either black or blue-black or black with the second abdominal segment orange above.

The species are wasps of medium to large size, ranging from about 10 millimeters for the smaller males to fully 25 millimeters for the larger females.

The characters of the genus may be summarized as follows: Medium to large sized wasps (10 to 25 mm.), colored either black, blue-black or black with the second abdominal segment orange above; posterior margin of pronotum, broadly arcuate in both sexes; clypeus of female deeply emarginate; males with a plumose plate at the base of the subgenital plate.

Male Genitalia.

A study of the male genitalia has been found of great help, particularly to supplement or verify certain external morphological characters. In fact it was due to a study of the male genitalia that the separation of *L. atrox* (Dahlb.) and *L. bengtssoni* n. sp. was made possible. Certain structural characters in specimens of these two species at first appeared to be merely structural variations. Later, after the genitalia gave unmistakable evidence of distinct species, these "variations" proved to be constant morphological differences, by which each species could be separated with little difficulty. The extent to which the genitalia can be used for the separation of species within a genus is, however, not without limitations. In Lophopompilus the genitalia show distinct constant differences by which each species can easily be identified. In the genus Batazonus Ashm. and certain other genera the genitalia for all the species are practically identical, although there are excellent external morphological characters by which these species can be separated.

The male genital structure (Plate XI, Fig. 1) is made up of two main parts, a basal portion or cardo, and an apical portion, which is composed of several parts. The cardo appears to show no specific differences. On the apical portion, or genital structure proper, there is (1) a central, rather flexible piece, the uncus, ("crochets" of Radoszkowski), which is incised apically and shallowly notched on each side. Extending from the median apical incision to the base is a chitinous thickening, which marks the division of this organ into two symmetrical halves and forms a longitudinal groove ("fourreau" of Radoszkowski) at the base of which on the ventral side is the

circular penial opening. Situated within the uncus and visible only with the higher magnifications of the microscope, is a longitudinal canal, which extends from the base to near the apex. (Plate XI, Fig. 5). Opening upon the surface of the uncus from this canal are minute pores, many of which are tubulate, and apparently furnished for the most part with microscopic surface spines. These tubular pores present a strikingly interesting pattern, but the arrangement appears to vary considerably, even in different specimens of the same species. (2) To each side of the uncus is a more heavily chitinized, rod-like organ, the saggitta ("la base du forceps" of Radoszkowski). These structures are destitute of hairs or spines and show only minor differences in shape and length as compared with the other structures, even in different genera. (3) Lying laterad to each sagitta is a structure which reminds one slightly by its shape of a bird's head, the apex being directed inward towards the uncus. The ventral surface, especially, of the volsellæ is covered with strong spines, some of which appear to have a tubular connection with a canal inside the structure after the manner of the tubular glands on the uncus. (Plate XII, Fig. 3). The volsellæ show specific differences both in shape and in the nature of the spinous armature.

At the base of each volsella is a group of strong hairs and mediad to these a pair of stout hooks, which are directed inwards. It might be noted that these hooks, here termed the basal hooks, are not present in all genera of the Psammocharinæ. These hooks show only slight differences in shape for the different species of the genus Lophopompilus. Radoszkowski has figured them in some of his plates and has mentioned them in the text. He appears, however, not to have named them.

(4) A pair of lateral organs, one lying laterad to each volsella, here termed the claspers ("branch du forceps" of Radoszkowski). These structures differ considerably in the different species in length and shape and in the nature of the vestiture, which consists of strong, long hairs. The claspers thus afford the most constant and pronounced characteristics of the male genitalia for the separation of the species of Lophopompilus. A small scale-like piece at the base of each clasper appears worthy of a designation, as its location on the

clasper varies in different genera, it even being lacking in some instances. This scale-like structure is here termed the genital squama.

Antennal Sense Organs.

It is not the intention of the present paper to go into morphological detail on this subject. It might be mentioned, however, that these organs are of distinct types in the two sexes and that certain groups of genera have antennal sense organs of a type distinct in structure from those of other groups of genera, the character evidently being of value for the grouping of genera into tribes.

There are two distinct types of antennal sense organs plainly visible under the binocular microscope (16 to 65 or more diameters) on the antennal segments of the females of Lophopompilus. One type, which will be referred to as the longitudinal sense organ, is located on about the anterior third (antennæ considered as extending sideways from the head) of each segment of the flagellum, except the first, on which it is absent near the base. This longitudinal sensitive area has the appearance of being covered with minute pores (Plate XIII, Figs. 3 and 7), but under high power (slide mount) it is seen to be covered with short, bluntly conical pegs, which closely resemble Schenk's "sensillum basiconicum," to which he attributes an olfactory function (Schenk—"Die Antennalen Hautsinnes-organe einiger Lep. und Hym.," Zool. Jahrb. Abth. fur Anat., 17, p. 573). The females of all species throughout the subfamily appear to have this longitudinal sense organ. A second type of sense organ upon the antenna in the females of Lophopompilus is also visible under the ordinary power of the binocular microscope. This consists of two more or less circular, depressed, shining areas on each segment of the flagellum. Each area occupies a central position, lying opposite to the other on the dorsal and ventral surfaces, the longitudinal sense area being between and contiguous to these on the anterior surface. These central sense organs are much larger on the apical segments than on the basal segments and the ventral area is considerably larger than the area opposite on the dorsal side of the same segment (Plate XIII, Fig. 3). These central sense areas are not present in Ashmead's genera Batozonus, Arachnophroctonus, Spilopompilus, Pycnopompilus and certain

other genera. Under high power the central sense areas appear to be dotted with minute pores, each of which gives rise to a slender bristle. It is probable that these organs have an auditory function.

In the males neither of the antennal sense organs described for the females occurs. The common type of antennal sense organ in this sex, with few exceptions, notably in Batozonus Ashm. and Poecilopompilus Ashm., occurs in the males throughout the subfamily. This sense organ consists of a light colored area covering the anterior half of all the segments of the flagellum, except the extremity of the apical segment. Sparsely set over this sensitive area are minute, erect, stout spines (Plate XIII, Fig. 4). Exceptions to this type of sense organ are to be found in the males of species of Batozonus Ashm. and Poecilopompilus Ashm. Here the only sensitive area visible under ordinary binocular magnification consists of a circular, depressed, shiny area at the base of each segment of the flagellum on the ventral side (Plate XIII, Fig. 6). These areas are especially conspicuous on the antennæ of species having dark colored antennæ, such as *Batozonus algidus* (Sm.)

Characters of Specific Value in the Genus Lophopompilus.

While a certain structure may be primarily of generic rank, that is, possessed in common by all species of a genus, there may be, nevertheless, some modification of this particular structure, which proves fairly constant for all specimens of distinct species, thus making the character of specific value also. For instance, the emargination of the clypeus in the female is a character common to all species of Lophopompilus, it thus being a generic character. In *L. atrox*, however, this emargination is narrow and deep, whereas in *L. bengtssoni* it is broad and shallow, this character, therefore, being of specific value in separating these two species. Unfortunately the emargination of the clypeus cannot be used for the males, as it does not occur in this sex. Another character of specific value, but one not available for use in all species of the genus is the comparative convergence of the eyes at the top of the head, and the comparative length of the postocellar and ocellocular lines. This character is especially advantageous in separating the species *atrox* and *bengtssoni*. The number and character of the anterior

metatarsal comb spines, although somewhat variable, nevertheless affords excellent means for separating the species of this genus. Here also this structure, although present in the males, is only weakly developed and therefore not as satisfactory a character as for the females.

Other characters that can occasionally be taken advantage of for separating species in this genus are color, vestiture, venation and slight differences in the thoracic structure. The male genitalia, as previously pointed out, offer excellent characters by which the species can be separated without difficulty, the claspers on this structure showing the most pronounced specific differences. This character cannot, however, be made use of for the ordinary key separation of species. The degree of excretion of the plumose plate at the base of the subgenital plate in the males appears to be fairly constant in some species and may, therefore, be resorted to, especially since in this sex the external characters for the separation of species are few in number. The use of separate keys for the two sexes is practically a necessity, as some of the excellent characters possessed by the females are lacking in the males.

It should be noted that even the most satisfactory and reliable specific characters in this group are somewhat variable. It is impossible to state that a certain character is invariably of a definite structure. It is only by taking the usual condition which obtains with respect to the more stable characters and by combining these with as many other characters peculiar to the species in question as possible that any degree of accuracy can be attained in the determination of closely allied species. Excluding the genitalia from consideration, the males of allied species are especially difficult to separate, on account of the frequency with which the characters overlap.

KEY FOR SEPARATION OF SPECIES OF LOPHOPOMPILUS.

(Females.)*

Color black, second abdominal segment orange above.

Emargination of clypeus broad and shallow; eyes converging more above, so that the postocellar line is longer than the ocellocular line; ocelli large and moderately prominent; anterior metatarsal comb spines usually four in number, the basal one sometimes reduced; basal and transverse median veins of the fore wings usually interstitial on the median vein, or these veins slightly disjoined, when disjoined the basal vein usually originating beyond the transverse median.... ..... *bengtssoni* (1)

Emargination of clypeus narrow and deep; eyes converging less above, so that the postocellar line is shorter than the ocellocular line; ocelli smäller, not prominent; anterior metatarsal comb spines usually three in number, occasionally a smaller fourth spine on one or both legs; basal and transverse median veins usually slightly disjoined on the median vein, the basal vein originating before the transverse median, rarely interstitial..... *atrox* (2)

Color, blue-black.

Edge of clypeus thickened and margined; its emargination broad and shallow and rounded where it meets the lower margin of clypeus; front convex, full between eyes, postocellar line distinctly shorter than ocellocular line; anterior metatarsal comb spines three in number, rarely with a smaller fourth, the terminal spine scarcely more than half the length of the second tarsal segment; metathorax with a moderately abrupt slope posteriorly and at the sides..... *æthiops* (3)

Edge of clypeus thin, its emargination rather deep, clean cut, and angled where it meets the lower margin of clypeus; front nearly vertical, head narrower antero-posteriorly, postocellar and ocellocular lines nearly equal; anterior metatarsal comb spines consisting of four long, strong spines, the terminal spine (if not worn) distinctly more than half the length of second segment; metathorax rounded posteriorly and at the sides..... *cleora* (4)

KEY FOR SEPARATION OF SPECIES

(Males.)†

Color, black, the second abdominal segment orange above.

Eyes converging more above, so that the postocellar line is longer than the ocellocular line; ocelli larger and moderately prominent; basal and transverse median veins of the fore wings usually interstitial on the median vein, or these veins slightly disjoined, when disjoined the basal vein usually originating beyond the transverse median; metathorax usually with an abrupt slope posteriorly. ..... *bengtssoni* (1)

Eyes converging less above, so that the postocellar line is shorter than the ocellocular line; ocelli smaller; basal and transverse median veins of fore wings usually slightly disjoined on the median vein, the basal vein originating before the transverse median, rarely interstitial; metathorax with a gradual slope posteriorly..... *atrox* (2)

Color, blue-black.

Front convex, full between eyes, postocellar line distinctly shorter than ocellocular line; anterior metatarsal comb spines three in number; plumose piece at base of subgenital plate exserted but little, more often with merely a tuft of hair evident..... *æthiops* (3)

Front nearly vertical, head narrower antero-posteriorly, postocellar and ocellocular lines nearly equal; anterior metatarsal comb spines four in number, the basal spine minute; plumose piece at base of subgenital plate exserted for nearly its entire length..... *cleora* (4)

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* The females have 12-segmented antennæ and dentate claws.

† The males have 13-segmented antennæ and cleft claws.

(1) **Lophopompilus bengtssoni** n. sp.*

Type—National Museum, Washington, D. C. Paratype, Am. Ent. Soc. Collection, Philadelphia; Montana State College Collection, Bozeman, Mont.; Massachusetts Agricultural College Collection, Amherst, Mass.

Distribution—New Hampshire, Durham, Hedding, Sept. 22, 1916; Massachusetts, Springfield, Amherst, July 28, 1890, July 6, 1900, August, 1909, September 14, 1916; Rhode Island; New York, Long Island, Fishers Island; Pennsylvania, October, 1908; North Carolina, Smith's Island, October, 1906; Georgia; Florida, Texas, Rosser, Dallas, August 5, 1908; Kansas, Meade County, Riley County, July 3; Illinois.

♀—Black, with a bluish tinge, second abdominal segment orange above on the anterior two-thirds of the segment, the band faintly interrupted in the middle and emarginate posteriorly; wings uniformly fusco-violaceous; emargination of clypeus broad and shallow (Plate XIII, Fig. 5); inner orbit of eyes slightly diagonal, the eyes converging somewhat above, so that the postocellar line is slightly longer than the ocellocular line; ocelli large, somewhat prominent, but front between eyes with a suggestion of concavity; anterior metatarsal comb spines four in number, the basal one sometimes smaller than the others, (Plate XII, Fig. 5); third cubital cell narrowed but little on the radial vein, basal and transverse median veins usually interstitial on the median vein, or these veins slightly disjointed; when disjointed the basal vein usually originating beyond the transverse median; cubitus of hind wings usually interstitial with the transverse median or arising before it scarcely more than the width of one of these veins; metathorax with a rather abrupt slope and somewhat flattened or concave posteriorly. Length, ♀, 15 to 25 mm.

♂—Similar to the female in color and venation; eyes converging above as in the female and postocellar line usually longer than ocellocular line, but this character often less distinct in the males than females; ocelli as in female, but front fuller between eyes than in the female; anterior metatarsal comb spines variable in number, even on the tarsi of the two legs of the same individual, often four in number, the basal spine weak and sometimes absent on one metatarsus, occasionally three on both legs; metathorax with a rather abrupt slope and somewhat flattened or concave posteriorly. Length, ♂, 13 to 19 mm.

Male genitalia (Plate XI, Fig. 1). This species is distinguished especially by the broad, flat claspers and the erect, narrow volsellæ.

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* Named after Dr. Simon Bengtsson, Curator of the Entomological Museum of the University of Lund, Lund, Sweden.

(2) **Lophopompilus atrox** (Dahlb.)*

Pompilus atrox Dahlbom, Hymen. Europ. I, 1843, p. 63.

Type, ♀, Museum of the University of Lund, Lund, Sweden.

Distribution.—Massachusetts: Amherst, July 10, 1895, Aug. 2, 1910, Springfield; New York: Ithaca, July 8, 1885, Long Island, Aug. 22; New Jersey: Anglesea, Aug. 8, 1901; Pennsylvania: Philadelphia; Delaware; Maryland: Chestertown; North Carolina: Raleigh, Oct. 1, 1900, July 10, 1902, Nov. 28, 1908, Wilkesboro, Aug. 9, Blowing Rock, Aug., 1906, Highlands, Sept., 1906, Smith Island, Oct., 1906; South Carolina; Georgia: Thomasville; Florida; Alabama: April 6, Oct. 14, 1903; Louisiana; Tennessee: Knoxville, May 12, 1891; Virginia: Richmond; Montana: Musselshell, Aug. 23, 1917, Aug. 23, 1915.

♀—Colored exactly like the preceding species; emargination of clypeus narrow and deep, (Plate XIII, Fig. 8); inner orbit of eyes almost a straight line, less diagonal and eyes converging less above than in *L. bengtssoni*, so that the postocellar line is slightly shorter than the ocellocular line; ocelli smaller than in preceding species and front full between the eyes; anterior metatarsal comb spines usually three in number, but occasionally with a small fourth spine on one or both legs, the one nearest the base usually the weakest, (Plate XII, Fig. 6); wings of the same color and cell arrangement as the preceding species; basal and transverse median veins usually slightly disjointed on the median, the basal vein originating before the transverse median, rarely entirely interstitial; cubitus of hind wings interstitial with the transverse median or arising but little or considerably before it in different specimens; metathorax with a more gradual slope posteriorly than in the preceding species. This species is on the average slightly smaller than *L. bengtssoni*. Length, ♀, 13 to 22 mm.

♂—Color similar to the female, blue-black with the second abdominal segment orange bove, a few specimens with a small spot of the same color on each side anteriorly of the third segment also; shape of head and relation of ocelli to eyes as in the female, except that in some specimens this character appears to be somewhat variable, in such specimens the postocellar line being about equal or even slightly longer than the ocellocular line; anterior metatarsal comb spines three in number, rarely with a minute fourth on one metatarsus; venation of wings similar to that of female; metathorax gradually sloping posteriorly. Length, ♂, 12 to 17 mm.

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* The identification of this species was made possible through the kindness of Dr. Bengtsson, Curator of the Entomological Museum of the University of Lund, Lund, Sweden, who examined the type.

Male genitalia (Plate XI, Fig. 2). The genitalia of this species are distinguished from the preceding by the shorter and narrower clasper, by the broader volsellæ and by the sparser and weaker hairs at the base of the volsellæ.

(3) **Lophopompilus aethiops** (Cress.)

Pompilus æthiops Cress., Proc. Ent. Soc. Philadelphia IV, 1865, p. 451, ♀; Trans. Am. Ent. Soc. I, 1867, p. 87, ♂ ♀.
Syn. *Psammochares ilione* Banks, Psyche, XVII, 1910, p. 249.

Type.—♂ ♀, Am. Ent. Soc. Collection, Philadelphia.

Distribution.—This is the most common and most widely distributed species of the genus. Vermont: Weston, July 31, 1901, Winooski, Aug. 14, 1901; Massachusetts: Amherst, Aug. 13, 1904, Sept. 15, 1914, Cambridge, Worcester, Nantucket, Aug. 16, 1911, Sept. 8, 1907; Rhode Island; New York: Ithaca, Aug. 8, 1903; New Jersey: Riverton, Sept. 8, 1901; Pennsylvania: Philadelphia, Sept. 7, Mt. Airy, Sept. 14, 1901; South Carolina; Nebraska; Missouri; Colorado; Arizona: White Oaks, July 21, 1902, Beulah, Aug. 17; Montana: Huntley, July 19, 1917, Aug. 23, 1915, Billings, July 30, 1910, Powderville, July 14, 1916, Laurel; Washington: Pullman, Aug. 26, 1908, Camp Umatilla, June 27, 1862, June 27, 1882, Yakima River (Lonetree) June 30, 1882, Wawawai, Sept. 6, 1908; California: Stanford Univ., Aug. 26, 1909, Sept., Oct., 1902, Palo Alto, May 7, 1910, June 11, 1896, Sept. 17, 1892; Mexico: Meadow Valley, Barbados.

♀—Blue-black; wings fusco-violaceous; edge of clypeus somewhat thickened and margined, its emargination rather broad and shallow, rounded where it meets the lower margin of the clypeus; front full between the eyes, convex antero-posteriorly; postocellar line distinctly shorter than the ocellocular line; anterior metatarsal comb spines three in number, rarely with a smaller fourth spine on one or both metatarsi; third cubital cell of fore wings narrowed little on the radian vein in some specimens, half or more in others, basal and transverse median veins either interstitial on the median vein or the basal originating slightly before the transverse median, position of cubitus and transverse median veins of hind wings variable, the cubitus usually originating slightly or considerably before the transverse median, occasionally these veins interstitial; metathorax with a moderately abrupt slope and somewhat flattened or concave posteriorly, rather abruptly sloping to the sides. Length, ♀, 13 to 23 mm.

♂—Color similar to the ♀; shape of head above and position of ocelli with respect to eyes as in the female; anterior metatarsal comb spines three in number; venation similar to the female; metathorax

rounded, slightly flattened or concave posteriorly; plumose piece at base of subgenital plate exserted but little and often with only a tuft of hair exposed through the emargination of the penultimate segment. Length, ♂, 9 to 16 mm.

Male genitalia (Plate XI, Fig. 3). This species is characterized especially by the comparatively long claspers, which are slightly enlarged and curved apically, and by the strongly curved and rather bluntly pointed volsellæ.

(4) **Lophopompilus cleora** (Banks).

Psammochares cleora Banks, Bull. of the Museum of Comparative Zoology at Harvard College, Vol. LXI, 1917, p. 105.

Type, ♀, Museum of Comparative Zoology, Harvard College, Cambridge, Mass.

Distribution.—This species is rather rare but appears to have quite a wide distribution. Massachusetts: Provincetown, June 29, 1891; Nantucket, Aug. 20, 1911, Sept. 5, 1907, Sept. 8, 1909; New York: Ithaca, Long Island, Rockaway and Wading River, Aug.; New Jersey: Ocean City, Sept., 1905, Anglesea, Aug. 8, 1901; Maryland: Chesapeake Beach, Sept. 21; Michigan: Huron Co., July, 1908; Montana: Laurel; Lower California: El Paraiso, May, 1889, Los Angeles, May 3 (Banks).

♀—Blue-black, with wings fusco-violaceous as in aethiops; edge of clypeus thin, emargination rather deep, clean cut and angled rather sharply where it meets the lower margin of the clypeus; front nearly vertical, the head comparatively narrow antero-posteriorly, postocellar and ocellocular lines about equal; anterior metatarsal comb consisting of four long, strong spines, sometimes with a smaller fifth comb spine on one or both metatarsi; also two small spines above the comb spines near middle of metatarsus, (Plate XII, Fig. 7); third cubital cell of fore wings narrowed little to one-half or more on the radial vein, basal vein usually originating slightly before the transverse median, occasionally these veins interstitial, cubitus of hind wings originating slightly or considerably before the transverse median; metathorax rounded posteriorly and at the sides, less abrupt than in *aethiops*. A smaller species than *aethiops*. Length, ♀, 13 to 15 mm.

♂—Color, shape of head, position of ocelli with respect to eyes and venation as in the female; metatarsal comb spines four in number, the fourth usually minute; metathorax gently sloping, rounded on all sides; plumose piece at the base of the subgenital plate usually exserted for nearly its entire length. Length, ♂, 10 to 13 mm.

Male genitalia (Plate XI, Fig. 4). This species is distinguished especially by the comparatively short claspers, which are rounded and but little widened apically. The volsellæ are more erect and more bluntly rounded apically than in *æthiops*.

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EXPLANATION OF PLATES.

PLATE XI.

Fig. 1. Genitalia of *L. bengtssoni*, ♂.

uc—uncus.
sg—sagitta.
vo—volsella.
cla—clasper.
gs—genital squama.
bh—basal hook.
po—penial opening.
co—cardo.

Fig. 2. Genitalia of *L. atrox*, ♂.
Fig. 3. Genitalia of *L. æthiops*, ♂.
Fig. 4. Genitalia of *L. cleora*, ♂.
Fig. 5. Enlarged drawing of uncus of *L. cleora*, showing tubulate pores.

PLATE XII.

Fig. 1. Plumose plate (B) at base of subgenital plate (A) in the males of the genus Lophopompilus.
Fig. 2. Penultimate ventral abdominal segment in the males of the genus Lophopompilus, showing emargination (C) under which the tip of the plumose piece (B) in Fig. 1 is exserted (see Fig. 4).
Fig. 3. Enlarged drawing of volsella of *L. cleora*, showing armature and tubulate glands.
Fig. 4. Side view of abdomen of ♂ *L. atrox*, showing exserted plumose plate (B) indicated in Fig. 1, B.
Fig. 5. Anterior metatarsal comb spines (4) in ♀ *L. bengtssoni*.
Fig. 6. Anterior metatarsal comb spines (3) in ♀ *L. atrox*.
Fig. 7. Anterior metatarsal comb spines (4) in ♀ *L. cleora*.

PLATE XIII.

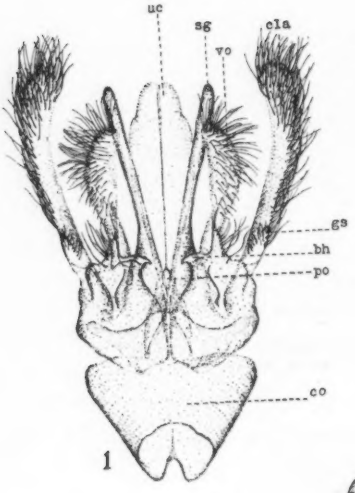
Figs. 1 and 2. Fore and hind wings of *L. atrox*.

a—anal vein.
ac—anal cell.
am—apical margin.
b—basal vein.
bl—basal lobe.
c—costal vein.
cc—costal cell.
cu—cubital vein.
cu_1—first cubital cell.
cu_2—second cubital cell.
cu_3—third cubital cell.
d—discoidal vein.
d_1—first discoidal cell.
d_2—second discoidal cell.
d_3—third discoidal cell.
fh—frenal hooks.
m—median vein.
mc—median cell.
r—raidal vein.
rc—radial cell.
re_1—first recurrent vein.
re_2—second recurrent vein.
s—stigma.
sc—subcostal vein.
sd—subdiscoidal vein.
sm—submedial cell.
sr—stigmal region.
tc—transverse cubitus.
tc_1—first transverse cubital vein.
tc_2—second transverse cubital vein.
tc_3—third transverse cubital vein.
tm—transverse median vein.

Fig. 3. Segments of antenna of female *L. bengtssoni*, showing longitudinal and central sense areas.
Fig. 4. Segments of antenna of male *L. bengtssoni*, showing sensitive area.
Fig. 5. Head of *L. bengtssoni*.

cf—clypeo-frontal suture.
cl—clypeus.
f—frons.
lb—labrum.
md—mandible.
ms—malar space.
ol—ocellocular line.
pl—postocellar line.
s—scrobes.

Fig. 6. Segments of antenna of male *Batozonus algidus*, showing sensitive area.
Fig. 7. Segments of antenna of female *Batozonus algidus*, showing sensitive area.
Fig. 8. Head of *L. atrox*.



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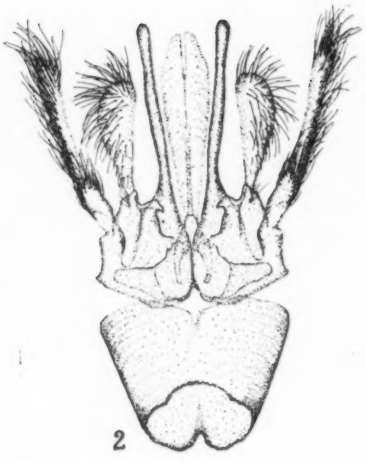

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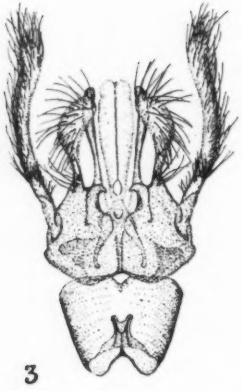

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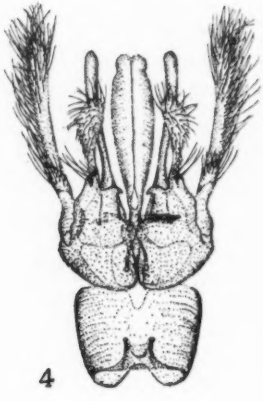

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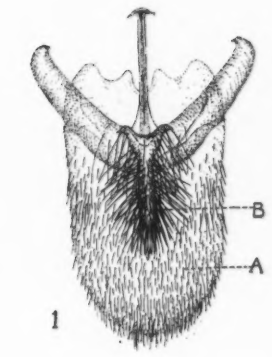

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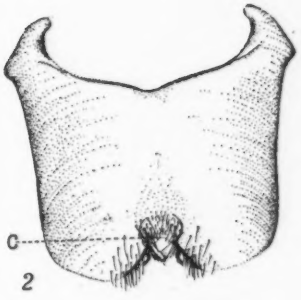

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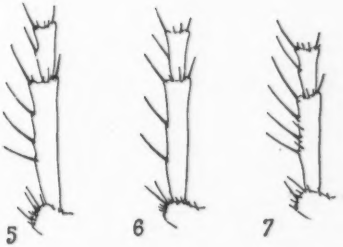

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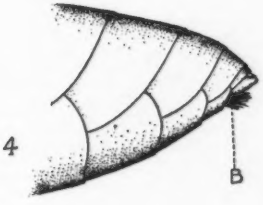

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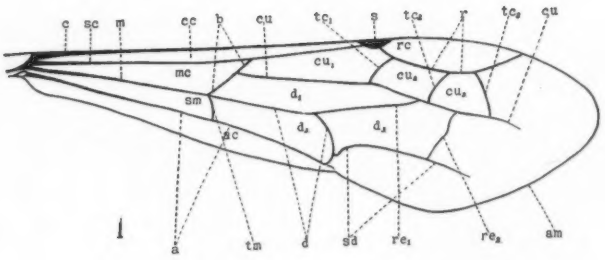
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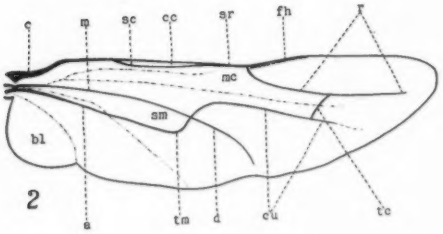
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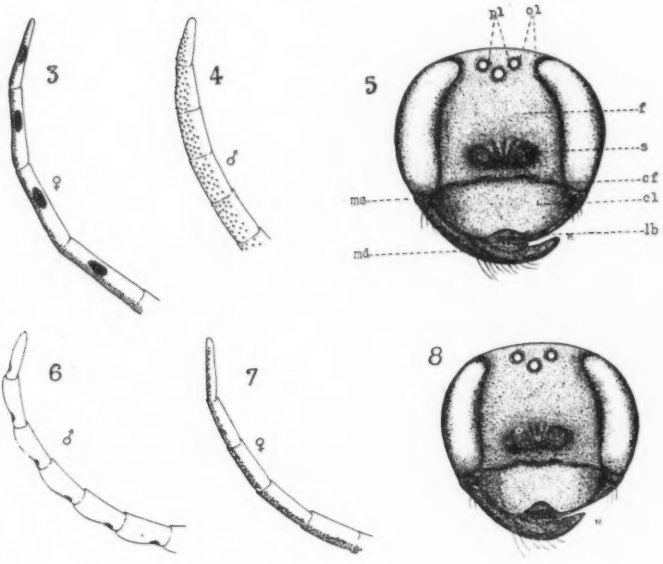
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W. S. Regan

THE BIOLOGY OF SCHIZASPIDIA TENUICORNIS ASHM., A EUCHARID PARASITE OF CAMPONOTUS.

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Introductory.

During the summer of 1921, while engaged in the study of the parasites of *Popillia japonica* at Koiwai, Iwate-ken, Japan, the writer occasionally made miscellaneous collections of parasitic Hymenoptera by sweeping. Among those secured was found at times numbers of a large metallic-green Eucharid. Realizing that the biology of this very interesting family of Chalcids had never been studied in detail, an effort was made to determine the habits of this species. In the localities where the parasite was abundant the large *Camponotus herculeanus* sub-sp. *japonicus* Mayr was very numerous, and was the only species of sufficient size to serve as host to the Eucharid. Several nests were therefore excavated, and the presence of the parasite in numbers in the cocoons was at once established.

The crucial point in this life-history was undoubtedly that of the place and manner of oviposition, as early experiments demonstrated that this did not occur in the normal manner. Sweepings of grass and weeds in the general vicinity of the nests produced a predominance of males over females in the ratio of about ten to one, an abnormal condition and one which led to the presumption that the greater proportion of the females were engaged elsewhere. Increased success resulted from sweepings on the lower branches of nearby chestnut trees, and this naturally induced a closer examination to determine the purpose of their presence in these places. A few days later, when attempting to capture a single female seen perched upon a chestnut bud, it was found that this individual had her ovipositor deeply inserted in the bud, in fact so much so as to be unable to withdraw it. An examination of the interior of this bud was then made, and there was revealed a large mass of very minute eggs closely packed within the terminal portion.

Being now in possession of what seemed to be the key to the problem, further observations were made in the same vicinity, and very soon hundreds of females were found ovipositing in an identical manner and place, and the egg-mass first seen was proved to be that of the parasite under observation. This important feature in the biology of the species thus being revealed, it remained to connect up the various stages, etc., to determine particularly the manner in which the larvæ from these eggs gain access to the *Camponotus* pupæ within cocoons in the soil. It soon became evident, however, that hatching was not to take place during that season, but that the eggs would remain in the buds throughout the winter. The investigations were thus brought to a close for the time being, to be continued and completed during 1922. The life-history as finally determined revealed a condition of affairs with hardly a parallel among the parasitic Hymenoptera.

Life-History of Schizaspidia tenuicornis Ashm.

Oviposition. As previously mentioned, the eggs are placed en masse within the buds of various trees, and pass the winter in this condition. The half-dozen or so buds at the terminal end of the young shoots were much preferred for this purpose. At Koiwai the favorite tree for oviposition was the wild mulberry (*Morus alba* L. var.), with the chestnut (*Castanea sativa* Mill.) ranking next. Occasional individuals were also seen to oviposit in white birch (*Betula* sp.). During the latter part of June, 1922, Mr. J. L. King observed egg-laying in the buds of oak (*Quercus mongolica* Fisch.) at Suigen, Korea, while Mr. K. Sato, of this station, noted the same thing in the large, fleshy buds of *Cladastis amurensis* B. et H. var. *floribunda* Maxim at Jozankai in Hokkaido, the most northern of the main islands of Japan. Further investigations in different localities will undoubtedly extend this list.

A comparison of the buds of these various trees shows that all have certain physical characters in common. They are non-resinous, and with the interior somewhat loosely packed, thus giving sufficient space for the egg-mass without undue pressure. Also, the buds of resin producing trees are usually too hard to permit of penetration by the ovipositor of *Schizaspidia*. It seems extremely probable that these physical characters alone

determine whether or not a plant species is suitable as a depository for the eggs of this type of parasite.

The number of eggs deposited by a single female was found to range from 940 to 1230, with a general average of 1050 for twenty-five egg-masses taken from buds in the field, and this was verified by a count of the mature eggs in the ovaries of the adult females. This number is in excess of that known for any other parasitic hymenopteron, and is a criterion of the mortality which must occur through the difficulties to be surmounted before the planidia finally gain access to the host larvæ in the nest beneath the surface of the soil.

The female penetrates the bud scales by the use of the ovipositor and sheaths combined, these being barbed at the tips. The point of insertion is invariably on the distal half, and usually on the upper side, though occasionally through the tip. The oviposition scars on the surface scales are evident as raised blackened spots about .5 mm. in diameter. On the inner scales the point of perforation is conspicuous as a much darkened area on the light green surface. The proper penetration of these scales to the interior of the bud requires about five minutes labor on the part of the female, and after this is completed the actual deposition of eggs begins. Under normal conditions the entire quota of eggs of the female is discharged at this one time, and is completed within an average period of twenty minutes. This represents a rate of oviposition of nearly one egg per second over the entire period, a most striking and unusual phenomenon, and comparable in rapidity to that of *Termes bellicosus* (Smeathman 1781) and *Pterodontia flavipes* (King 1916), though of much shorter duration.

The stalked eggs, having passed through the ovipositor, lie free within the bud cavity, or the space normally occupied by the tips of the inner scales and the pubescence, and all are liberated at approximately the same point. As the eggs continue to issue from the ovipositor tip those first laid are forced further and further away. This force, being always from the center of the mass outwards, tends to arrange the eggs in irregular concentric circles about this point, with the stalks directed somewhat towards the center.

The completed egg-mass, comprising a thousand or more eggs, conforms in outline to the space available in the bud. Usually it approximates 1.5 mm. in length, slightly less in width,

and of varying depth. Its center on the outer surface is represented by a hard, dark-brown mass, of about the volume of half a dozen eggs, which may be either a hardened fluid given off by the female at the time of oviposition or merely an exudation of sap from the lacerated tissues of the inner bud scales.

The number of these egg-masses within a single bud may be determined approximately by a count of the oviposition scars on the surface. As many as twenty-four, of normal size, have been taken from a single large mulberry bud collected in the field. In such cases the composite mass has a pronounced stratified appearance due to the difference in age of the successive individual egg-clusters. Figure 1 of Plate XV shows two egg-masses of characteristic form and position within a mulberry bud. That on the left is freshly laid, while the other is about twenty days old and consequently much darkened.

The one tree in the buds of which the greater proportion of the eggs were laid was a small mulberry bush about seven feet high, and not heavily branched, growing in a strip of waste land. In 1921, from a count of the twigs bearing buds suitable for oviposition, it was estimated that approximately six hundred buds were available for oviposition by *Schizaspidia*. Eighty-five of these were cut open and examined under the binocular. Every one was found to contain eggs, and the average was 7.2 masses per bud. Allowing one thousand eggs per mass, this being very near the general average as determined by actual count, we secure the almost unbelievable total of 4,320,000 within the buds of this single shrub. In the case of a few buds the pressure had become so great through excessive oviposition that a small number of eggs were actually forced out through one or more of the puncture holes. At times every bud on a twig would bear one, and sometimes two, females in the act of oviposition.

Oviposition on bright days occurs largely during the morning from 9:00 A. M. to 12:00 M., though a few individuals could be seen here and there during the afternoon until as late as 4:00 P. M. These late females were largely those which had been disturbed during the morning hours and had not succeeded in relieving themselves of their burden of eggs.

The Egg Stage.—When first laid the stalked eggs are white in color, but at the end of about fifteen days they show a pronounced darkening due to the development of the embryo

within. After twenty days the larva is fully formed and its general characters may be readily distinguished through the transparent chorion. Under the binocular the latter is seen to give off brilliant irridescent reflections. The general color of the mass itself is a deep amber. The larva occupies less than half the volume of the egg, and the remainder is filled with a nutrient fluid of a colloidal nature, and immersed in this medium the larva remains through the winter. At this time the body segments are lightly chitinized and the large head fully formed.

During the early spring when tree growth begins (mulberry the latter part of April at Koiwai, chestnut about two weeks later) the flower buds first swell and burst through their scaly covering, being followed shortly by the leaf buds. As the heavy scales which have protected them during the dormant season fall away it is seen that the *Schizaspidia* are firmly attached to the fine, leaf-like inner scales. They are now exposed to the sun, rain, and other detrimental influences, and finally fall to the ground. In the very humid climate prevalent at Koiwai these mold very quickly, and none remain from the opened buds to reproduce the species. By May twentieth no exposed egg-masses could be found on the trees or elsewhere. The same course of events took place in the case of chestnut buds a few weeks later.

Upon the trees, however, there still remains a considerable number of buds which have failed to develop, and within these the remaining eggs are contained which serve to perpetuate the species. Being dead, these buds eventually dry out, and some open slightly, thus producing a means of egress for the imprisoned larvæ after hatching. The same result is secured in other buds by the feeding of bud-moths and other insects.

During the spring months the larva within the egg completes its development, apparently consuming the greater portion of the fluids surrounding it and leaving only the remnants of the amnion and a granular residue at the anterior end. Hatching is effected by a break in the chorion near the posterior end, this taking place during July, though live, unhatched larvæ were found in buds as late as August 28th.

First Larval Stage (Plate XV, Figs. 2–5).—The newly hatched planidia, scarcely more than one-tenth of a millimeter in length, are capable of locomotion to a limited degree. This is accomplished by a looping movement wherein the suctorial

mouthparts are attached to the surface and the small attachment disk of the caudal segment brought forward into position, after which the head is again moved forward. The heavy paired spines on the four caudal segments, and particularly those of the last two, assist in bracing the body when the planidia are in a more or less upright position, as when waiting for some insect or other object to which to attach themselves. This position is not at right angles to the surface of the object, but consists merely in the elevation of the anterior two-thirds of the body to an angle of about forty-five degrees. When in this alert position the planidium extends its mouthparts much as illustrated in Figs. 2 and 3, but during cool periods, or when resting, these are retracted into the body, and the heavy dorsal "plate" of the head is brought to a position at right angles to the axis of the body, and appears as a much darkened base upon an inverted cone, as represented by the body proper.

By the looping movement above referred to the larvæ succeed in making their way out of the buds which have sheltered them for so many months. This being accomplished, they wait about for some means of transportation to the ant nest. At this time the mulberry trees are laden with ripe fruit, and chestnut trees frequently have heavy infestations of aphis. The workers of *Camponotus* visit these trees in numbers to feed upon the decaying fruit and upon honey-dew, and in their movements about the twigs and foliage give the parasite larvæ an opportunity to attach themselves to the hairs of the tarsi and other portions of the body. Figure 13 illustrates the position in which several of these were found.

Having now arrived at the nest the larvæ may eventually be brushed off during the movements of the workers about the chambers among the larvæ or they may be removed during the process of cleaning indulged in by the workers after a foray in search of food. They manage, largely by chance, to become attached to the ant larvæ and, after moving about over the body for a time settle dorsally in one of the sutures between the head and the first thoracic segment, or between the first two of the latter. The mandibles are then imbedded firmly in the derm of the host and no further movement takes place.

Second Larval Stage (Plate XV, Fig. 6).—The larva moults by a transverse dorsal split in the derm of the thoracic regions, and the posterior portion of the exuvium is sloughed off cau-

dally, while the head of the second stage larva is lifted out of the anterior portion and reapplied to the host at a point slightly behind the previous one. A form more characteristic of the greater proportion of ectoparasitic larvæ is now assumed. The mouthparts are suctorial, with no evidence of mandibles. Attachment to the host is maintained by means of the adhesive pad made up of the cast skin of the first stage, the mandibles of which are still firmly imbedded in the derm. In dorsal view the head "plate" of the exuvium is visible on the antero-ventral margin of the first thoracic segment. With the parasite in this stage the semipupa of *Camponotus* is clearly evident within its envelope, and within a short time a rupture appears on the median dorsal line of the thorax, the exuvium then being gradually forced back over the body and finally placed at the posterior end of the cocoon. During the process of ecdysis the parasite larva struggles to free itself from the cast skin and, eventually succeeding, works its way slowly back to the desired position on the body of the newly formed pupa. With its very limited powers of movement this reattachment is possible largely because the pupa is now enclosed within its cocoon, thus retaining the parasite in close proximity to its own body. It was a rather remarkable and unexpected development to find that the second stage, rather than the first, effected this transposition from the host larva to the pupa, and it would seem that this is a further handicap imposed upon the species. It would appear more logical for the first stage to continue until the final place of development is reached.

The place of attachment to the host pupa is almost invariably on the metathorax, just underneath the wing-pads or the hind legs, though in a few cases observed the larvæ were slightly more caudad, being on the first abdominal segment. Development now takes place very rapidly, and the second moult occurs within twenty-four hours after the transformation of the host.

Third Larval Stage (Plate XV, Fig. 7).—Having now reached the final larval stage growth becomes very rapid. The position on the host pupa is identical with that of the late second stage. The mouthparts are strictly suctorial, and with no evidence of mandibles. The oral orifice is surrounded by a lightly chitinized ring, and within the buccal cavity is the sharp, stilleto-like "plunger," which serves to perforate the derm of the host and

to keep the aperture open. In living individuals this can be seen moving back and forth with the regularity and almost the speed of a trip-hammer, and functioning as the piston within a cylinder. The power thus exerted is sufficient to drain from the host pupa the last drop of its fluid contents without a change in position. A semi-diagrammatic sketch of these mouthparts, showing the limits of movement of the "plunger," is shown in Fig. 10.

The above type of mouth structure is quite unique among the parasitic Hymenoptera. Normally all stages are equipped with mandibles, though among ectoparasites feeding in the first two stages is largely by suctorial action. In the third, however, the mandibles are well developed and feeding is completed by devouring the tissues remaining, this often going so far as to include the entire chitinous derm of the host. *Schizaspidia* in this stage more nearly approaches the type of mouthparts borne by certain of the parasitic Diptera rather than those typical of the Hymenoptera.

The tracheal system, which could not be distinguished in the first two stages, is now propneustic, only one pair of spiracles being present and these placed laterally on the second thoracic division.

As feeding is completed within a few days after the second moult it is evident that the host pupa is not able to progress far in its development. No appreciable effect is produced by the presence of the first and second stages on the body, and consequently the pupa is of normal size and form in every respect. The third stage parasite larva however, drains the body so rapidly and thoroughly that no parasitized pupa is ever able to advance sufficiently to exhibit any traces of pigmentation in the eyes, the first organs to exhibit coloration in normal individuals.

In the nests of *C. herculeanus* sub-sp. *japonicus* at Koiwai during August and September may be found the cocoons of queens, males and major and minor workers. With the exception of the pupæ of the queens and major workers a single parasite is capable of consuming the entire body contents, and all that remains is the perfectly transparent, collapsed pupal envelope. In the case of the larger individuals only a portion of the body fluids are withdrawn, though death is nevertheless effected. Occasionally two larvæ may be found upon a single

host pupa, and in such instances their position is symmetrical with respect to the body of the host. Figure 8 shows a half-grown *Schizaspidia* larva in characteristic position upon a male pupa.

Pupal Stage (Plate XV, Fig. 9). The third and final larval ecdysis invariably takes place *in situ*, the remains of the host serving as a ventral cushion upon which the parasite pupa rests. Moulting is effected by a median dorsal split on the thorax, and the exuvium is then forced backwards over the body and is finally left between the caudal end of the pupa and the host remains. If the cocoon contains two parasite pupæ these always assume positions facing each other, and with the empty pupal skin of the host between them. In all such instances observed both individuals were of the same sex.

The pupa is at first of an opaque, whitish color, and of the form represented in the figure. The characteristic intersegmental welts extend over three sides of the abdomen, and are slightly more pronounced on the caudal segments. The males may be readily distinguished by the longer antennal sheaths. Pigmentation sets in very shortly and the coloration and surface markings of the developing adults become clearly visible through the derm.

The Adult (Plate XIV).—The final transformation having taken place the adult remains within the cocoon for one, and occasionally two, days before emerging. This is then effected by the cutting away of a perfectly regular cap from the anterior end of the cocoon, the cut representing two-thirds of the circle and the cap remaining attached by one edge. Crawling out of the cocoon the parasites wander about the nest for a time and then escape into the open air. No assistance whatever is rendered by the ants of the colony at the time of emergence, nor are the parasites disturbed or interfered with in their movements.

In the laboratory several colonies were confined in artificial nests for observation as to the relations existing between the adult parasites and the ants themselves. Having no means of egress from the nest the parasites wandered aimlessly about and exhibited not the slightest interest in the larvæ or cocoons of the host. Occasionally they would be seized by workers and carried to the refuse heap, but without injury. Later, weakening through their fruitless wanderings, they are dismembered by the worker ants in exactly the same manner as decrepit

individuals of their own species. No instance was ever observed of workers feeding the parasites, and likewise repeated efforts to induce them to partake of honey or sugar solution resulted negatively. None were seen in the field visiting flowers or partaking of food in any manner, and it is therefore very probably that this species abstains wholly from feeding during its short adult life.

Dissections of adult females not yet emerged from the host cocoons revealed the fact that practically the entire quota of eggs in the ovarian tubes is already mature, and the gestative period is therefore reduced to a minimum. Counts of the fully-developed ovarian eggs yielded from slightly over nine hundred to eleven hundred, practically the number which is eventually deposited. Oviposition normally occurs on the day of emergence from the *Camponotus* nest.

Observations on emergence from several field colonies and on a considerable quantity of collected material gave the females predominance in numbers of two to one, and this is in accordance with the general ratio known to exist among the greater proportion of the Chalcidoid Hymenoptera.

Mating takes place almost immediately after the emergence of the female from the nest. On warm days, from 9:00 A. M. onwards, it was possible to observe swarms of males, numbering in some cases upwards of one hundred individuals, hovering in the air one or two feet above the entrance to the ant nests. The assembling of the males under these circumstances may be induced by the nest odor, though it is possible that the presence of the females themselves in the burrows can be detected. As the females first emerge into the light they are immediately pounced upon by the males, and mating takes place immediately and before the former are able to take to flight. Mating apparently occurs only once, as it has never been observed in places other than above mentioned, and laboratory experiments have failed to induce copulation except with newly emerged individuals.

The length of life of the adults of this species is extremely short, and under field conditions does not extend over more than three days following emergence from the nest. As oviposition occurs on the day of emergence, or the following day at the latest, the essential function of the individual is fulfilled and death takes place with little delay. In the laboratory,

under conditions inhibiting oviposition, females were kept alive for a maximum of five days.

No secondary parasites have thus far been found upon *Schizaspidia tenuicornis*. A considerable number of eggs are devoured or destroyed by an undetermined bud-moth on mulberry, while numerous adults fall prey to the large Asilid, (*Promachus yesonicus* Big.). However, the greatest loss among the adults is brought about by spiders of the family *Thomisidæ*, which abound upon the foliage of trees and shrubs, and which feed upon any of the smaller insects which they are able to catch. The female *Schizaspidia*, having begun oviposition, are unable to take wing quickly and are consequently very easily captured by the spiders. However, the combined loss from these natural enemies is not great.

Life Cycle.—During the season of 1921 the first adults were collected by sweeping on August 20th, though judging from the quantity of eggs later found in the buds they must have been present for some time previously. The maximum numerical abundance was attained about August 27th, and all adults had disappeared by September 15th. An examination of *Camponotus* nests at this time revealed the fact that all pupæ had developed and emerged, and only eggs and first stage larvæ were to be found. During the following season this locality was visited frequently in order to determine the date of first emergence. Two females were found ovipositing on August 14th, and their appearance in numbers from that date onwards was rapid. The greatest numbers were present on August 21st and 22nd, and none could be found after September 7th. This, then, also represents the period over which eggs are deposited.

In Korea emergence took place much earlier in the season, as ovipositing females were taken by J. L. King at Suigen during the latter part of June, 1922, the host in this case possibly being *C. herculeanus* sub-sp. *ligniperdus* var. *obscuripes* Mayr, as *C. herculeanus* sub-sp. *japonicus* does not mature sufficiently early to permit of the development of the parasite at this date.

At Jozankai, Hokkaido, Mr. K. Sato observed adults in numbers on August 5th, but not a single one could be found by the writer when he visited the same locality on August 31st.

In order to appreciate the significance of these varying times of emergence it is necessary to know certain facts in the

life-history of the host. At Koiwai *C. herculeanus* sub-sp. *japonicus* passes the winter in the egg and first larval stages, and by the middle of May all are in the second instar. In 1922 the first cocoons were found on July 11th, and a very few of these contained advanced first stage *Schizaspidia* larvæ. It is, of course, evident that no parasites can develop on this host until the pupal stage is reached, and consequently, by force of necessity, its advanced stages are limited strictly to the two months following the above mentioned date. The Korean *Camponotus* above mentioned attains the cocoon stage earlier in the season, and accordingly the development of the parasite is advanced to that extent. Jozankai, Hokkaido, being in a more northern latitude, has a much shorter summer season, and *Schizaspidia*, as well as most other insects, appears later and does not persist so long as at Koiwai.

Referring once again to the latter place, where observations were most complete, we have the eggs deposited in buds during the month following August 14th, and with the planidia within the eggs well developed twenty days later. In this condition they pass the winter and spring months. The first eggs hatch late in June and the larvæ crawl out on the twigs and foliage to await some means of transportation to the ant nest. Apparently solely by chance an occasional planidium succeeds in attaching itself to a worker ant as the latter wanders over the tree in search of food. Being transported in this way it reaches the nest and finally gains its place upon an ant larva. The first moult takes place before the host pupates, the second immediately after pupation, and the third less than one week later. Next comes the pupal stage of about six days, followed by a day of rest and finally emergence into the open air. The duration of the various stages of *S. tenuicornis* may therefore be given as follows:

Egg stage	approx. 11 months
First larval stage	20 days
Second larval stage	3 "
Third larval stage	4 "
Pupal stage	6 "
Adult, within the cocoon	1 "
Adult, outside the nest	2-3 "

This life-cycle contrasts very strikingly with that of such Chalcidoid Hymenoptera as are at present known. The egg stage in this super-family is normally of very short duration,

ranging from one to four days, and extended to seven to ten days in the case of *Perilampus*.

Habitat. The necessity for oviposition within the buds of various trees and shrubs has the effect of greatly restricting the general distribution of this parasite. Nests of *Camponotus* fifty or more yards distant from such trees were entirely free from attack. At Koiwai the district within which the parasite was extremely abundant comprised an area, about one hundred yards square, of waste land overgrown with weeds and bordered on one side by a grove of chestnut trees. In the center of the plot were two small mulberry trees, one of which has been referred to as containing such a great quantity of eggs. Nearby was one large birch tree, a few pines and miscellaneous shrubs. The elevation is approximately 1200 feet, and the climatic conditions somewhat comparable to those of the north central states, though the summer season is characterized by almost daily rains and with a constantly high atmospheric humidity.

General Considerations.—There are several points in the life-history of *S. tenuicornis*, as presented in the preceding pages, which give ground for much cogitation. The first of these is the early loss of such a great proportion of the eggs through the shedding in the spring of the bud scales to which they are attached. That the bud should open and develop is a normal sequence of events and it seems illogical that this should lead to the destruction and utter loss of the larger portion of these eggs. Those remaining in dead buds are often permanently imprisoned, while the remainder, after hatching and emerging from the buds, must depend solely upon chance for a means of transportation to the nest, and even when this is attained their very limited powers of locomotion render small the likelihood of the actual attainment of the position necessary to further development. It would seem, under these combined influences, that even the five-hundred-fold potential rate of increase would hardly be sufficient to compensate for all the adverse factors present.

An interpretation which was considered at one time was that of the egg-masses, as they fell from the trees during the month of May, being occasionally gathered up by the worker ants and stored in the nest with the brood, and their care by the ants over the following period of about two months. This theory is supported by the fact that the larva is not of the

true planidium type, having but limited powers of locomotion, and possibly requiring care and attention if it is to reach maturity. To test out this point a number of egg-masses were placed in an isolated corner of an artificial nest and the reactions of the ants observed. When first discovered the masses were examined carefully and finally carried into the inner chamber and placed among the larvæ. This appeared somewhat promising, but the following morning revealed them on the rubbish heap. Other egg-masses placed in the nest were discarded immediately. In the field none of these were ever found in the nests, though admittedly it would be easily possible to overlook them even were they present.

The main consideration which would seem to render the above interpretation untenable is the number of eggs in a single mass. In 1921 the average number per bud was 7200, and if only a single one of these masses were taken into a nest comprising several hundred larvæ the latter would certainly be annihilated. As a matter of fact, from the ten million or more eggs deposited that season within the limits of an area about one hundred yards square, less than one thousand adults were finally produced the following summer, a reduction in numbers of about ninety per cent as compared with the preceding season. The mortality in the early stages was therefore about 99.99 per cent. The highest degree of parasitism in any single nest observed during 1921 was 47 percent as compared with 16 percent for the following season. This result is diametrically opposed to that which we would have every right to expect were the above theory based upon fact.

It is conceivable that under different climatic conditions the egg-masses fallen from opening buds would contribute to the perpetuation of the species. As previously mentioned, the excessive humidity and daily rains prevalent at Koiwai during the summer season were conducive to extensive molding, and egg-masses placed in the open air were destroyed in a few days, the infection starting from the decaying bud-scales and quickly extending through the masses. In a dry climate it is possible that some of these egg-masses would fall in such a position as to be sheltered from direct sunlight and other detrimental influences, and be able to live and develop normally during the month or more preceding hatching. This having been accomplished, their opportunity to gain access to the ant nests would be equal to that of larvæ hatched from dead buds on the trees.

Another point in the life-history of this species which would seem to work to its disadvantage is the fact that the first larval ecdysis occurs prior to the attainment of the final position for development on the host pupa. While the planidium itself has no remarkable powers of locomotion, yet its capabilities in this respect are much greater than those of the second stage. It appears however, that the commencement of histolytic action preparatory to pupation provides the initial stimulus to development, and a moult consequently is forced prior to the transformation of the host larva to the pupal stage. Were the latter not enclosed within a cocoon it is very improbable that the parasite in its second stage would be able to regain connection with its host. For this reason it would seem necessary, in such species of ants as produce naked pupæ, for the Eucharid parasite to persist in the unfed planidium stage until attachment to the pupa is accomplished or, on the other hand, to complete its development before ecdysis actually takes place.

The remarkable habit of an insect parasitic upon the immature forms of ants in nests in the soil depositing its eggs in the buds of trees leads one to wonder as to the means by which such a habit could have been brought about. There are no parasitic groups among the Hymenoptera which are known to exhibit this marked departure from the normal, nor anything even more analogous to it, and we are thus left without a clew as to its origin. Were it suggested that the species had been originally a plant feeder and later developed its parasitic propensities, we are confronted by the fact that the entire family *Eucharidæ*, so far as known, is parasitic exclusively upon ants, and consequently parasitism must have been one of the earliest developments in the phylogeny of the race, and that the oviposition habit is a more recent departure. Any conjectures which we might make in this respect would be entirely in the realm of speculative entomology, and as such would be of little value.

Salient Features in the Biology of Schizaspidia tenuicornis.

1. The eggs are deposited en masse in the buds of various trees, and there pass approximately eleven months of the year.
2. Egg-masses in buds which develop normally in the spring are a total loss, only those in dead buds serving to perpetuate the species.

3. An average of slightly more than one thousand eggs is produced by each female, and these are all deposited within a period of not more than twenty minutes, or at the rate of about one per second.

4. The planidium, having emerged from the bud, gains access to the nest of *Camponotus* by attaching itself to a worker ant as the latter moves about the tree in search of food.

5. The second stage larva, rather than the first, effects the transfer from the cast larval skin to the pupa of the host.

Literature on the Biology of the Eucharidæ.

Considering the great extent to which ants and their associated insects have been studied in various parts of the world it seems remarkable that so very little has become known regarding the *Eucharidæ*. Host records are numerous, but further than this little is available. Forel (1890) first recorded a species of this family (*Eucharis myrmeciæ* Cameron) as parasitic upon ants, and gave a general description of the third stage larva. He reached the conclusion that *Eucharis* is parasitic upon the mature larvæ of *Myrmecia*, and this is doubtless true in the earlier stages, but it is very possible that transferrence to the pupa takes place just as in *Schizaspidia*.

The next, and last, contribution to our knowledge of this group was that by Dr. W. M. Wheeler (1907), wherein was presented an extended exposition of the biology of *Orasema viridis* Ashm., with notes on *O. coloradensis* Ashm., *O. wheeleri* Ashm., and *Pseudochalcura gibbosa* Provancher. As there are radical differences in the biology of *O. viridis* as presented by Dr. Wheeler, from that of *Schizaspidia*, it may be well to make a comparison of the two.

In general form the planidium of *Orasema* is very similar to that of *Schizaspidia*, though the latter is unique in having a heavy armature on the caudal segments instead of the usual unjointed stylets. The supposed banded second stage of *Orasema* is unquestionably an advanced first, and is similar to that of *Schizaspidia* and *Perilampus* (Smith 1912). The actual second stage is not mentioned or figured, unless it is his figure 16, though this has more the appearance and size of the early third, and resembles that of *Schizaspidia*. We now come to a rather surprising development in the biology of *Orasema* as compared with that of other Chalcidoid Hymenoptera, and this

is the intervention of two additional instars between the third larval and the pupa, namely, the pustulate fourth and the semipupa. These are entirely absent in *Schizaspidia*.

Orasema is said by Dr. Wheeler to emerge from the nest and mate in the open fields, and then to return and oviposit directly upon the mature larvæ and semipupæ. While the egg itself was never observed by him yet the probable manner and place of oviposition were discussed at some length. The need of a high potential rate of reproduction was attributed to the great danger of the egg becoming detached from the host. Smith (loc. cit.) in reviewing this portion of the paper, questioned this interpretation, and, assuming a parallelism in habit between *Orasema* and *Perilampus*, presented the hypothesis that the eggs are not laid in the nest at all, but upon flowers or other vegetation frequented by the parasite adults and worker ants; that the eggs hatch and the planidia in some manner attach themselves to these workers and are conveyed to the nest; and finally, that these planidia are at first endoparasitic, later emerging and completing their development as ectoparasites. It is possible that Mr. Smith's interpretation of this latter point may have been modified after his finding of *Perilampus chrysopæ* var. (1921) developing externally through all its larval stages upon *Chrysopa*.

Knowing now the life-history of *S. tenuicornis* in considerable detail it is possible to draw some conclusions as to the probable true state of affairs in the biology of *Orasema viridis*. Smith's assertion that oviposition occurs outside the nest is undoubtedly correct, though the likelihood of the eggs being placed upon flowers or foliage is small. In this connection it must be borne in mind that no trace of the parasite in any stage could be found in the *Pheidole* nests during the autumn, winter and early spring months. It is therefore probable that the winter is passed in the egg stage as in *Schizaspidia*, and such being the case they must be placed in some more sheltered position than is secured by indiscriminate oviposition upon foliage. Whatever occurs, the planidia upon hatching must be carried into the nests by the worker ants, as they are of a type very similar to that of *Schizaspidia* and probably possess no greater powers of locomotion. In case more than one generation per year is produced, and the appearance of adults in May makes this quite possible, it would necessitate a modification

in the manner and place of oviposition, yet this presents some difficulties. Might it be that the eggs of the spring brood of adults are placed in the seed-capsules of certain annuals rather than in the buds of trees?

In concluding this consideration of the biology of *Orasema viridis* it may be said that every known fact in its life-history points to a fundamental similarity to that of *Schizaspidia tenuicornis*.

Literature on the Biology of Perilampus.

In the family *Perilampidæ*, very closely allied taxonomically to the *Eucharidæ*, we find the only instances of oviposition entirely apart from the host that have heretofore been known to occur among the Chalcidoid Hymenoptera. Smith's contributions to the biology of the genus *Perilampus* constitute the only information available upon this extremely interesting group. One of its notable features is the great diversity shown to exist among the hosts, this being at present known to range over five different orders of insects, as contrasted with the single superfamily to which the *Eucharidæ* are apparently restricted.

The planidia of the species studied by Smith have far greater mobility than is evidenced by that of *Schizaspidia*, and this is made necessary by the habits and location of the hosts. Morphologically they are very similar, except that the former bears an extensive armature entirely lacking in *Schizaspidia*, but with a pair of unjointed stylets on the caudal segment in place of the five pairs of very heavy lanceolate spines on the four terminal segments of the latter. *Perilampus* is doubtless a more primitive form, and the greater specialization of *Schizaspidia* has rendered the above type of armature superfluous.

The habit of bud-oviposition herein recorded for *Schizaspidia* represents a considerable advance over the more or less indiscriminate leaf-oviposition of *Perilampus*. It may be asserted that certain of the *Leucospidæ* are at present in the incipient stages of development of a habit similar to that of the latter genus. According to Fabre (1886) the egg of *L. gigas* is placed within the cell of the mason-bee (*Chalicodoma muraria*) but not directly upon the host larva. The resulting first stage larva is of the planidium type and bears ventrally on each segment a pair of ambulatory setæ. The gap separating this departure

from the normal from that of *Perilampus* is not great, but neither gives a clew to the manner in which bud-oviposition, with its consequent prolongation of the egg stage to approximately eleven months, could have been brought about.

Oviposition Habits in Other Parasitic Groups.

Among the *Tachinidæ* the habit of leaf-oviposition has been demonstrated in the genus *Crossocosmia* by Sasaki (1887), in *Chætogædia* by Swezey (1908) and in *Blepharipa* by Townsend (1908). In other families, such as the *Bombylidæ*, oviposition is said to take place upon blossoms, etc., frequented by the hosts. Certain of the *Dexiidæ* scatter their eggs or larvæ promiscuously upon the surface of the soil, and the planidia burrow about in search of Scarabæid larvæ within which to develop. Several writers have observed the oviposition of *Oncodes* (fam. *Cyrtidæ*) upon twigs, and more recently King (1916) presented a detailed account of the biology of *Pterodontia flavipes*, parasitic upon Lycosid spiders. Oviposition takes place upon the trunks of trees, and the resulting planidium is very similar to that of *Perilampus*, both in form and habit. Modifications of the above oviposition habits are known to occur in other orders, such as the Coleoptera, and may even extend to the little-known group of parasitic Lepidoptera (fam. *Epipyropidæ*).

Among the parasitic Hymenoptera *Perilampus* has heretofore been the only group in which leaf-oviposition was known to occur. In an as yet unpublished paper Mr. Cho Teranishi, of this station, records the same habit in the family *Trigonalidæ*, and it is quite possible that this phenomenon will eventually prove to be much less rare than has thus far been supposed.

Descriptions.

ADULTS. (Plate XIV).

Female (Fig. 1).—Head nearly twice wider than deep. Lateral ocelli separated by half the distance between the eyes at the vertex. Mandibles (Fig. 1a) long, sickle-shaped, the left with one large tooth near the base, the right with two, which are subequal; two long spines on the inner edge near the base. Labrum palmate, with 8–11 digits, these produced at the tips. Antennæ 12-jointed, 2.2 mm. in length; the scape one-half longer than wide; pedicel as wide as long; first flagellar joint longest, one-third as wide at the tip as long; the second two-thirds as long as the first; those remaining of decreasing length, except the eighth, which is equal to the seventh, and the last, which is longer

than either of the preceding four. Ratio, 6:4:14:9:8.5:8:7.5:6.5:6:6: 5.5:7.

Fore wings 4.5 mm. in length, 1.6 mm. in width; veins in the ratio of 22:11:1:4; marginal vein obscured by a fuscous cloud, which broadens below. Alar expanse 11 mm. Hind-wings 2.7 mm. in length, .6 mm. in width; the submarginal vein extends to the hooks, which are four in number; posterior margin from the tip with a fringe of fine ciliæ.

Femora of fore-legs thickened and broadest at the middle; tibial spur with a tooth near the apex, which is lacking on the spurs of the mid- and hind-legs. Tarsal joints in the ratio of 12:4.5:3:2:8.

Abdomen visibly six-segmented, the first longer than the remaining five combined; all posterior margins emarginate medially. Petiole slightly shorter than the femora of the hind legs (10:11), somewhat dilated at the middle. Ovipositor barbed at the tip.

General color of the head and thorax metallic blue-green with bronze and purple reflections. Antennal scape, pedicel and basal half of first flagellar joint yellowish-brown, the remainder dark brown. Mandibles yellowish, with the inner margins black. Legs yellowish, except the coxæ, which are of the general body color, with the distal margin brownish; the last tarsal joint dark. Petiole testaceous, and broadly ringed with fuscous at the middle. First segment of the abdomen black, the remaining five testaceous except for a fuscous band at each posterior margin. In dried specimens the segments are largely retracted into the first, and the testaceous areas largely concealed.

Head with the transverse striations on the face, these turning upwards and curving around and between the eyes; vertex longitudinally, occiput transversely striate. Thorax generally foveate-punctate except the parapsides and episternum, which are smooth, with marginal punctuations. Outer face of the middle coxæ with large, shallow punctures. Petiole slightly rugose.

Length, 5.0–6.0 mm.

Male (Fig. 2).—Head slightly wider proportionally than in the female. Antennæ 12-jointed; length, 3.2 mm.; scape one and one-half times longer than wide; pedicel as wide as long; first six flagellar joints slightly swollen at the tips; tapering somewhat distad from the middle; first flagellar joint one-fifth as wide as long; ratio 7:4:23:18.5:17.5: 16:16:15:14:13:14.5.

Fore wings, length 4.0 mm., width, 1.5 mm.; alar expanse, 9.5 mm. Hind wings, length, 2.5 mm.; width, .5 mm.

Petiole longer than the hind femora (20:12). Abdomen of three visible segments, the first much the largest, and in dried specimens enclosing the second and third.

General color of the head and thorax metallic indigo-blue with bronze reflections. Petiole dark brown, with the base yellowish. First abdominal segment black, the second and third testaceous.

Punctuations of the thorax uniform with that of the female except the parapsides, which are shallowly, uniformly punctate instead of smooth. Petiole slightly rugose at the base.

Other characters as in the female.

Length, 4.5–5.5 mm.

Specimens were submitted to the U. S. National Museum for comparison with Ashmead's types of *S. tenuicornis*, and the determination verified by Mr. A. B. Gahan. The types, according to Gahan, comprise one female, lacking antennæ, and one male, the abdomen of which is missing. The original description of the female (N. Y. Ent. Soc., XII, 2, p. 151. June, 1904) apparently combines the characters of both sexes, as the antennæ described are certainly those of the male.

The species figured by Matsumura (Classification of Insects. Vol. II, p. 283, Pl. V, Tokyo, 1915) as *S. tenuicornis* is of some genus other than *Schizaspidia*.

Host.—*Camopnotus herculeanus* sub-sp. *japonicus* Mayr, and probably other members of the same genus. Such host relationships of other members of the genus *Schizaspidia* as are at present known indicate that it is restricted largely to this one group of ants.

Habitat.—Japan (northern Hondo and Hokkaido) and Korea.

Immature Forms.

(Plate XV).

The Egg (Fig. 11). Mature ovarian egg .125 mm. in length, .06 mm. in width, and with a stalk .23 mm. in length at the posterior end. This stalk is dilated at its distal end to three times the diameter at the middle.

After being laid, the main egg body is slightly increased in size, being .135 mm. in length, with the stalk measuring .21 mm. The latter is somewhat collapsed, due to a portion of the contents having been forced into the main body. Color white, and semitranslucent.

First Stage Larva (Figs. 2–5). Length fully extended, .1 mm.; width, .04 mm., and thickest at the thoracic regions, tapering sharply caudad. Segments nine in number, with no appreciable distinction between the thorax and abdomen. Head, .03 mm. in length, very deep brown in color, heavily chitinized, rounded at both ends, and tapering slightly cephalad. The heavily chitinized portion does not extend ventrad. The mouthparts comprise a membranous funnel terminating in a chitinized, transversely striate, ring. The mandibles (Fig. 12) are strong, heavily chitinized, with an excision at the base of the inner edge, and situated within the buccal cavity.

Body segments lightly, uniformly chitinized, pale amber in color, and tapering caudad, each fitting telescopically into the one preceding. The fifth (not counting the head), sixth and seventh each bear a pair of heavy spines ventrally near the lateral margin, these increasing the length on the successive segments. The terminal segment with two pairs of very heavy, lanceolate spines 10 μ in length.

The advanced first stage larva (Fig. 5) is .25 mm. in length and marked dorsally with six transverse bands, the first being widest and uniform throughout its length, the second and third slightly widened medially, and the remaining three somewhat linear. The two caudal segments show no distention. The elastic integument between the bands is uncolored.

Second Stage Larva (Fig. 6). Length, .6 mm., and with the nine segments distinct. The head is small, unchitinized, and placed ventrally beneath the first thoracic segment. The latter large and hemispherical, the second shorter, and the next five subequal, with the last longer and narrower. Mouthparts suctorial, with no evidence of mandibles. Color translucent, with the yellowish contents of the digestive tract clearly evident through the derm.

Third Stage Larva (Fig. 7). Immediately after the ecdysis 1.0 mm. in length, increasing to 6.0–7.0 mm. at the end of the stage. Possibly nine-segmented, the lines of demarcation indistinct at first and later entirely obliterated except for that between the head and thorax, between the first and second thoracic segments, the latter and the third apparently being fused, and a distinct division between the thorax and abdomen. The body therefore comprises only four main divisions; namely, the head, the first thoracic segment, the second and third combined, and the abdomen, the latter being much the largest. The caudal segment bears ventrally a conspicuous tubercle representing the anal orifice. Color opaque-white, with the derm thickly and uniformly set with minute raised dots, which produce a slightly roughened appearance.

The mouthparts (Fig. 10) are suctorial, comprising an oral opening at the base of a circular depression having a lightly chitinized rim, and within the buccal cavity a heavily chitinized and sharply pointed stylet, or "plunger." Immediately below the oral orifice are two bulbous prominences, doubtless homologous to the maxillæ, while above are two inconspicuous protuberances representing the antennæ.

Pupa (Fig. 9). Length, 5.0–8.0 mm., and 2.5–3.0 mm. in width at the posterior part of the abdomen, the widest point. Three conical protuberances are present dorsally on the head, these being superimposed over the developing ocelli. A number of similar prominences occur on the thorax. The abdomen bears five transverse intersegmental welts, which do not extend ventrally.

Color at first pure white, but later showing clearly the coloration and surface markings of the developing adult through the transparent pupal envelope.

The male is smaller and similar, but distinguished by the much longer antennal sheaths, these extending to the middle of the abdomen.

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EXPLANATION OF PLATES.

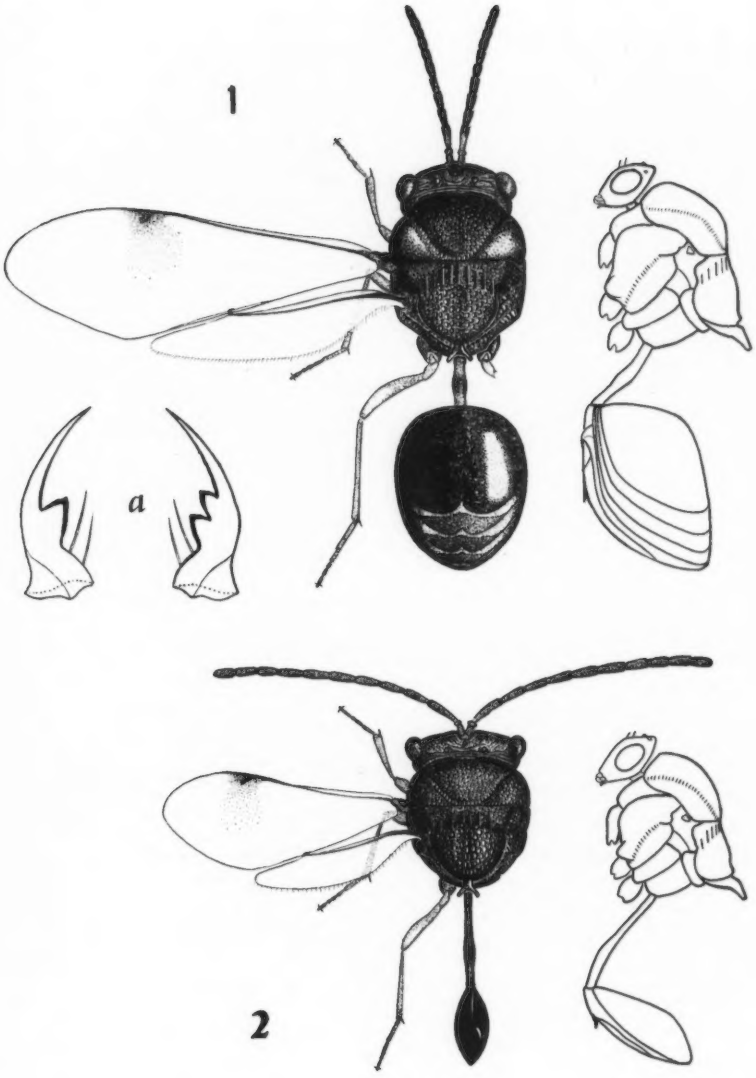
Schizaspidia tenuicornis Ashm.

PLATE XIV.

Fig. 1. Adult female, dorsal view, with profile. (x 11). a. Mandibles.
Fig. 2. Adult male, dorsal view, with profile (x 11).

PLATE XV.

Fig. 1. Mulberry bud with scales removed to show two egg-masses in situ. (x 20).
Fig. 2. First stage larva, lateral view. (x 500).
Fig. 3. First stage larva, dorsal view. (x 500).
Fig. 4. First stage larva, lateral view, with head retracted. (x 500).
Fig. 5. Advanced first stage larva, dorsal view. (x 200).
Fig. 6. Second stage larva, dorsal view. (x 85).
Fig. 7. Third stage larva, lateral view. (x 10).
Fig. 8. Third stage larva in situ on male pupa of *Camponotus*. (x 9).
Fig. 9. Female pupa, lateral view. (x 10).
Fig. 10. Sagittal section (diagrammatic) of the mouthparts of the third stage larva.
Fig. 11. Ovarian egg. (x 100).
Fig. 12. Mandibles of first stage larva.
Fig. 13. Three first stage larvæ adhering to the leg of a *Camponotus* worker. (x 50).



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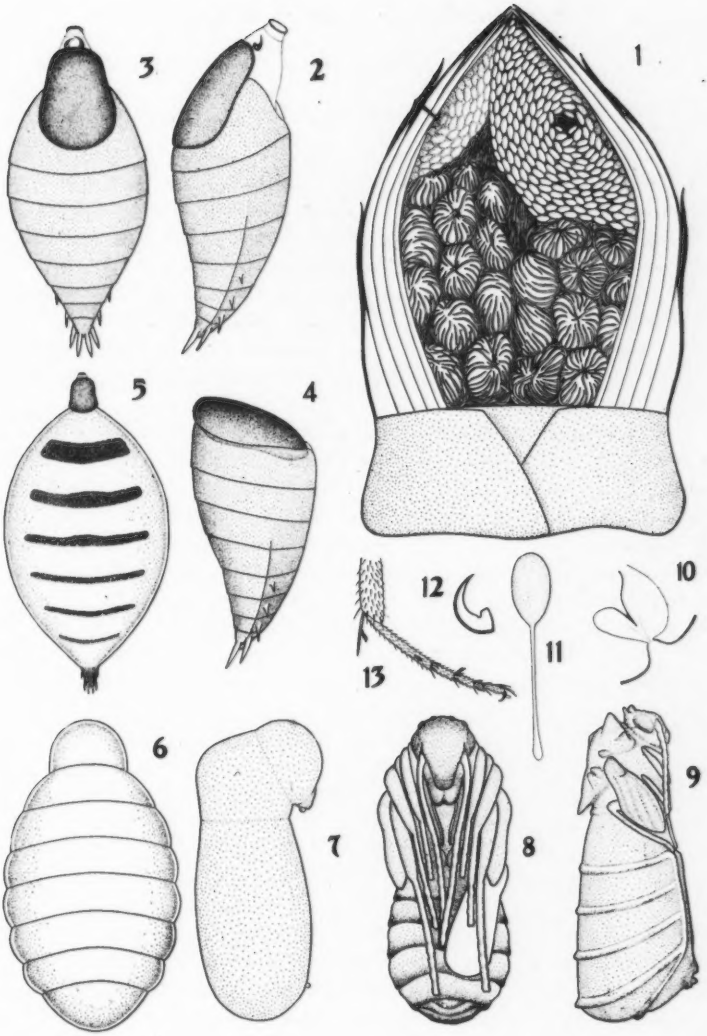

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THE BIOLOGY OF THE STAPHYLINIDÆ.

By HELEN G. MANK.

INTRODUCTION.

This paper is an account of the life histories and habits of several Staphylinidæ. The adults of this large family are too well known to require any particular description. The active, elongate beetles, with their short elytra that leave exposed most of the abdominal segments, are found in a variety of places. Many are carrion feeders and are popularly associated with the Silphidæ by reason of their similar habits. They are also found in dung, in ants' nests, under the bark of trees, on the moist banks of streams and ponds, and in decaying animal or vegetable matter of all sorts.

The enormous number of species in this family has resulted in a considerable amount of work on the adult forms, but the study of the early stages of these beetles has been much neglected and in many cases these stages are entirely unknown. Probably the reason for this is because these insects have been considered of no marked economic importance. The larvæ are not unusual or beautiful enough to attract the casual observer to a closer investigation. As a consequence, collections of thousands of adults may not contain larvæ or pupæ of a single species. Published accounts of this family seldom include any special description of the larvæ or pupæ.

I wish to express my thanks to Prof. J. G. Needham, who directed the work of this paper, for his encouragement and help, and to Mr. H. C. Fall, who named the specimens under discussion.

HISTORICAL.

The comparatively few life histories hitherto studied have mostly been by three Frenchmen, Mulsant, Rey, and Xambeu. The other life histories that have been worked out, only some half dozen in all, are either unusually large and conspicuous types or they are forms that are parasitic on some insect pest and so, are of economic importance. A great proportion of the European forms described are not found in this country and therefore, the descriptions are not so useful to us.

The earliest account of the life history of forms in this group is a description of the larvæ of Staphylinus æneus, Staphylinus variabilis, and Xantholinus punctulatus in Bouchè's "*Naturgeshichte der Insecten*," published in Berlin in 1834. The descriptions are accompanied by drawings. The number and size of the teeth on the upper lip, a character that figures prominently in later papers, is hardly suggested in his plates.

The best accounts of the larvæ of the Staphylinidæ published are those by Schiodte, which appeared in 1864. His work includes many valuable drawings of both larvæ and pupæ, accompanied by brief but concise descriptions in Latin. The types he studied include two species of the genus Philonthus, five of Bledius, two of Quedius, and one each of Oxyporus, Ocypus, Xantholinus, Staphylinus, and Platystethus. Many of these belong to the larger forms in the family.

In 1875 Mulsant had published a description of Philonthus æneus, first described by Bouche as Staphylinus æneus.

In the section on Brevipennis in Mulsant and Rey's great work, "*Histoire Naturelle des Coléoptères de France*," 1877, the authors give scattered accounts of larvæ together with their descriptions of the adults. For instance, in the large genus Philonthus, there are descriptions of only eight larvæ and of these several of the species are not positively known. The plates illustrating the larvæ differentiate them wholly by the posterior end of the body.

Schaupp in the Bulletin of the Brooklyn Entomological Society for 1878, 1879, and 1880 published an account of the life history of Staphylinus vulpinus, Staphylinus maxillosus, and Listotrophus cingulatus. A few diagrams illustrate the text. Here again the forms chosen are among the largest in the family.

In 1886 Rey published an article giving a general description of Staphylinid larvæ followed by a more detailed account of a number of species. His work, together with that of Mulsant seems to have been the inspiration for Xambeu's articles later.

Certain of the Staphylinidæ are parasitic and their life history, therefore, has been of economic importance. A Cornell Bulletin for 1894 by Slingerland gives an account of Aleochara nitida, which is parasitic on the cabbage root maggot. A Minnesota Bulletin for 1908 mentions the same insect as an enemy of the cabbage root maggot.

Chapin ('15) gives a brief description of Xantholinus cephalus which was reared in plaster of paris casts.

The widest general view of the life histories in the family as a whole is found in several series of articles published by Capitaine Xambeu in *Le Naturaliste* and in *L'Éxchange*, 1907 to 1913. He not only describes a large number of species in genera representing all the sub-families; but in several genera, notably the genus Philonthus, he attempts to establish a basis of classification of the larvæ and suggests a possible method for determining the pupæ. Unlike the work of Wadsworth and others who have studied the parasitic Staphylinidæ from an economic standpoint Xambeu is interested mainly from the view of pure science. In both series of articles he introduces the paper by an account of the copulation, egg-laying, larvæ, and pupæ of the group as a whole. This is followed by a description of a large number of species. He makes his classification of the larvæ on the followed characters:

1. Upper lip.
2. Antennal lobes and terminations.
3. Length of caudal styles and pseuopode.

The second he considers the least valuable inasmuch as the segments of the antennæ and the other appendages are so easily broken off that many specimens could never be identified if that were the only basis. In each case he mentions the relative size and appearance of the caudal appendage but the real basis of classification he makes on the condition of the upper lip, or "lisiere frontale."

The most detailed as well as the most recent paper dealing with the life history of any of the Staphylinidæ is that of Wadsworth in the Journal of Economic Biology for June, 1915, in which he discusses the rove beetle parasitic on the cabbage root maggot. Other authors dealing with the same subject have described it as Aleochara nitida; Wadsworth, however, found all but one of some two dozen beetles that he raised to be Aleochara bilineata. He collected puparia of the cabbage fly every month in 1914, April and May excepted, and also in the early months of 1915. With a strong light the puparia containing parasites were detected. These were placed in glass topped boxes containing sterilized sand. Adult beetles emerged and were kept alive in captivity as long as three months. Living larvæ and the contents of puparia were given the beetles for

food, and the entire life cycle was observed in the laboratory. Detailed descriptions illustrated by plates are given of the ova larvæ, pupæ and imagoes.

MATERIAL.

The material for this paper was collected at Ithaca during the summer of 1919. The subject was suggested when a large number of rove beetles appeared in decaying vegetable matter in which flies were being bred. Plants of various kinds were ground up in a clover cutter and the material placed in cake tins. To induce flies to lay their eggs on this pulpy mass, it was baited with ground-up apple, hawthorn, grape or canteloupe and exposed to the air. The upper layers soon turned black, due to the oxidation of the broken plant cells, although in several cases the lower surfaces remained green indefinitely. Exposed to the air and to the changes of weather, some of the pans became wet and soggy, while those that were sheltered remained comparatively dry. Within a few days the mass was teeming with life. Dipterous larvæ of many kinds were most numerous but Coleoptera of several families were fairly abundant. Small Hydrophilidæ were found in the wettest of the pans; one or two of the Nitidulidæ were frequently found in the decaying fruit; but by far the commonest beetles were the Staphylinidæ. It is with these that this paper deals.

The first beetles were taken July 2 and others were collected at intervals of a few days until the latter part of August. Pans of vegetable substance in which they were found ranged all the way from nine days to two months old. The amount of decomposition in the plant material appeared to make no difference in the number of beetles, but the amount of moisture was of the greatest importance. The kind of plant used had some effect on the appearance of the beetles, although that again may have been mainly a question of moisture. The largest numbers of beetles were found in a combination of alder and touch-me-not, and in sweet clover. As to age, in one case nine days proved long enough to raise a swarm of fly larvæ and an abundance of rove beetles, and the oldest of the pans still had some insects. Where rain had fallen into the pans until they had become a wet, slimy mass, few beetles appeared although there was an abundance of fly larvæ. Mold, also, seemed an unfavorable environment. Rather dry material on the other hand, practically always showed a large number of Staphylinidæ.

The beetles, both larvæ and adults, were usually securely hidden in the material and when a pan of it was suddenly overturned they would go scampering away in all directions. Although their usual method of locomotion is walking, they can fly readily. They are extremely lively and elusive creatures but when once caught in the open, the larger ones especially, stand perfectly motionless with the flexible abdomen tipped over the back in a decidedly menacing attitude. They are not provided with any sting so their only means of defense is to emit a disagreeable odor, from the posterior end of the body. William Beebe, in an article describing army ants, says that these rove beetles were tolerated among the ants when any other living thing would have been destroyed immediately. A crippled ant hobbling along got out of the main line. Several beetles pounced upon it. A group of ants rushed out to join the conflict, whereupon the beetles raised their abdomens and ejected a drop of liquid and at that the ants were utterly confused.

Types found. A great number of the beetles captured or raised belong to the genus Philonthus. Philonthus brunneus was extremely common, and Philonthus longicornis was found frequently, while Philonthus cyannipennis appeared now and then. Specimens of Philonthus æneus and Philonthus lætulus were also taken. During August Belonuchus formosus came in great numbers, especially in the driest of the pans. Tachinus flavipennis and Tachinus pallipes (?) were common. Nearly every time that beetles were collected one or two specimens of Listotrophus cingulatus were found. One specimen of Siagonum americanum was taken. This is usually found under bark and as the pans were kept in a grove of hemlocks its presence was probably an accident.

Methods of raising. Both larvæ and adults were hardy and easily kept in small tin salve boxes which were half filled with moist sand. A bit of the disintegrating vegetable material from the pans was added to give the same general environment as that in which they had been found. This vegetable substance was full of Dipterous larvæ and mites and from time to time more larvæ were added. The Staphylinidæ were so easily raised that in about six weeks over twenty were reared from the larval to the adult stage in these little boxes.

Food. The strong curved mandibles of the larvæ bespeak a ferocity of habit that is well borne out by investigation. They

seem to be used for grasping their prey. I found no evidence that the larvæ actually eat their victims. Rather they seem to seize the fly larva and then suck out the juices. Often I noticed that the first incision was near the middle of the body of the fly larva. When food was put into the box the beetle larva ran around continuously but I could never induce the larva to eat while the box cover was off. Probably that was due to the light for the larvæ were always found far down in the midst of the vegetable substance away from the daylight. The larvæ are omnivorous in their habits. Larvæ of muscids and other Diptera were eaten readily. In two cases I fed them entirely on mites and they grew well. By accident two Staphylinid larvæ were left in the same box and one promptly devoured the other. In another instance a larva was put in a box with a pupa and the larva broke a hole in the covering and sucked out the juice. They thrive on a variety of food, both as to kind and as to amount. The amount of food that was definitely put in was no true estimate, however, for whenever vegetable matter was introduced it was full of minute forms of life.

LIFE HISTORY.

Egg Laying.—Xambeu gives an interesting account of the copulation and egg laying habits of these beetles. Reproduction usually occurs in the spring, rarely in autumn. Copulation may last for several hours or even a day. The eggs are laid under the dead body of some animal or in some other place already provided with food, that is, in decaying animal or vegetable matter or wherever Dipterous larvæ are to be found. The place is usually found by the olfactory sense of the female. She digs an oblong trench in the soil or other material with her anal segment and then deposits six to eight eggs in it, one at a time, and covers it all with earth or with food. The egg is so large in comparison with the size of the ovipositor that the act of egg laying is exhausting and the female usually dies soon afterward.

The egg is oval, a yellowish white, finely striated longitudinally. After eight to ten days it opens lengthwise.

Larvæ.—Larvæ were never found as abundantly as were adults among the vegetable mass. In fact, I often found adults without a sign of the larvæ. These were usually to be found in dry substances and when one appeared often a number were found. These varied from very young ones, hardly more than a millimeter in length to an occasional giant an inch long. The larva of most of the forms studied was about 7 mms. long. The general shape of the larva is slender and tapering. They are active creatures, constantly crawling here and there in search of food among the stuff in which they live. The head is

subquadrate, reddish brown in color, and heavily chitinized. The antennæ arise at the base of the mandibles and are four-jointed. The first segment is short and broad; the second, long; the third, long with a supplementary joint on the inner side; the fourth, short with a brush of stiff hairs at the tip. The mandibles are chitinized, strong, and sickle-shaped. The first joint of the maxillæ is short and broad, the second is more slender and twice as long, with a small immovable lobe on the inner margin. The palpus is made up of five small segments. The mentum is short, the ligula, shorter, the palpi are small and vary in number. There are several long hairs on both the antennæ and the maxillæ and these hairs and even the lobes themselves are easily broken off.

Ocelli.—In some families the number and position of the ocelli are so constant that they may be used to distinguish the family from its near relatives. In Schaupp's description of the larvæ of this family, he distinguishes them from the Carabidæ by stating that the Staphylinidæ have one claw and four ocelli, while the Carabidæ have two claws and six ocelli. In MacGillivray's key to the Coleopterous larvæ he places Staphylinidæ under the head of "ocelli usually 4." In the larvæ that I have examined I found that there were usually 4 ocelli, three together and one a little posterior, but in one species, *Tachinus flavipennis*, I found six distinct ocelli in two rows, four in the anterior and two in the posterior row.

In examining Xambeu's published descriptions I found the greatest divergence in the number and appearance of the ocelli in this family. Not only is there no constancy in the family as a whole, but even in a single genus among closely related forms there is all manner of variation in the ocelli. The number ranges all the way from one to six. Some are so nearly like the color of the background that they are indistinguishable from it while many have conspicuous black or brown spots. Sometimes several form a confused group so that there seems to be but a single spot. In location they are placed at the base of the mandibles or the antennæ. Often when four or more are present they seem to be in two groups. Three close together and one posterior is a common arrangement. When there are but three they often form a triangle. Five may be grouped as four and one or three and two. Six may be grouped as four and two or three and three.

It is quite natural for the authors mentioned above to give the number as four without further comment since the forms described were all among the Staphylinidæ that ordinarily do have four ocelli.

The following table compiled from Xambeu's descriptions gives some idea of the amount of variation among the different forms:

TABLE SHOWING NUMBER OF OCELLI IN THE LARVÆ.

Atheta testaceipes	One dark point at base of mandibles.
Atheta crelata	Five, four above and one below.
Atheta Pertyi	One point.
Falagria amicula	Group of confused black points.
Leptusa solifuga	Three reddish spots in triangle.
Leptusa laticornis	Ocelli very small in form of cross.
Placusa complanata	Black elliptical spot in each cheek.
Cyphena curtuta	Large black spot.
Gyrophæna affinis	Small black spot.
Gyrophæna manea	Large black spot.
Phytosus nigriventus	Small triangular spot.
Oligota flavicornis	Small black spot.
Conurus littoreus	Six, four above and two below.
Tachinus rufipes	Five, four in arc, one behind.
Tachinus laticollis	Six, four in front, two behind.
Tachinus subterraneus	Six, four in one line, two in other.
Tachyporus brunneus	Five, three and two.
Bolitobius exoletus	Confused group.
Velleius dilatatus	Three large black spots.
Staphylinides	Four in line or in circle around protuberance.
Othius myrmecophilus	One large point.
Baptolinus affinis	Three in triangle.
Midolius collaris	Shining elliptical spot.
Xantholinus punctulatus	Four or five points at posterior angle of head.
Xanthelinus tricolor	Brown spot.
Lathrobium augustatum	Confused group at base of antennæ.
Lathrobium mutipunctum	Three or four.
Medum aveyronnensis	Five, three and two.
Pæderus tempestivus	Six, three and three.
Platystethus cornutus	Striking black spot.
Platystethus spinosus	Not apparent.
Platystethus nitens	Intense black spot.
Oxytelus picens	Black point.
Oxytelus sculptus	Large rounded point.
Bledius tricornis	Three in semicircle.
Ancyrophorus flexuosus	Three in triangle.
Ancyrophorus omalinus	Three in triangle.
Syntomium æneum	Confused with background.
Micralmia marinum	Five, four and one.
Omalium	Five in arc of circle.
Antholium	One large spot.
Proteinus ovalis	Three in semiarc.
Proteinus limbatus	One shining black spot.
Megarthrus affinis	One point.

Upper Lip.—The larvæ of the Staphylinidæ have a peculiar upper lip with a toothed margin. The homology of this region has not always been clear. Sharp says that the Staphylinidæ have no labrum. Schiodte calls this region the epistoma. Kemner describes it as frontale and clypeus. Wadsworth names it the upper lip. Xambeu calls it the "lisiere frontale," or frontal border. On the basis of the number and character of the teeth on the margin he classifies a large number of the larvæ that he describes. Of nineteen species of Philonthus that he

describes, all but one readily fall into this system of classification and he says that many other genera would be as easily distinguished by this character. In his later and more extensive papers in *L'Éxchange*, it is interesting to see how far this rule may be applied. This character cannot be used in the case of the Aleocharinæ, Tachyporinæ, Xantholindes, Paederinæ, Oxytelinæ, Oxyporinæ and Omaliens, but it is useful among Philonthus, Quedius and Staphylinus, in fact among most of the Staphylininæ. Where it is applicable it is most convenient, since it is constant, easily seen, easily described, and unlikely to be broken off or obliterated in any way.

Pseudopode.—One of the characteristic features of the Staphylinidæ is the cylindrical organ at the posterior end of the body. It is called "pusher" by Ganglebauer and "pseudopode" by Xambeu. "Pusher" is an excellent descriptive term, for the larva uses it as such whenever it walks. It is in use most of the time apparently, for the little creature is moving all the time from the minute it is out of the egg until a day or two before pupation. The pseudopode is a fleshy, cylindrical organ, as long or a little longer than the first segment of the anal style. The two anal styles flank the pseudopode and are set at an angle to it. They are biarticulate. The second segment is very slender and is terminated by a bristle.

Molting.—Xambeu says that there are three molts at least. I found two in Philonthus cyannipennis, but very likely the larva had molted once before I captured it. Philonthus cyannipennis and Listotrophus cingulatus both leave their skins, but with the smaller forms no trace of the larval skin is left except when it goes into the pupal stage. Xambeu says that they eat their skins. All these transformations occur at night.

Pupæ.—Pupæ were seldom found in the pans of vegetable substance, but larvæ placed in the salve boxes readily transformed. For a day or two previous the larva was very quiet and neither moved nor ate. Then the larval skin would break down the back and morning would find the shining, yellowish brown pupa, thoroughly chitinized, in the midst of a little nest in the damp sand. In every case the transformation took place at night. Occasionally the larval skin did not break far enough for the creature to emerge and the larva died then and there. Kellogg says, "The pupæ of some species are enclosed in a sort of exudation that dries into a firm protecting coating rather like the horny cuticle of a Lepidopterous chrysalid." I found this in Tachinus flavipennis, but in no other.

The pupa rests on the dorsal side with the head curved downward. On each side is a piece of chitin in the form of a coil. On the border between the head and the first thoracic segment is a fringe of hairs varying in number according to the species. This makes one of the best ways of classifying different species by the pupæ. The only difficulty is that these hairs are readily broken off. The dorsal side is somewhat depressed with a large spiracle visible in the anterior corner of the first abdominal segment and a small one in the anterior corner of the next

three segments. The body tapers to the last segment, which terminates in two anal styles which are biarticulate and end in a spine. Stiff hairs project laterally from the abdominal segments. These I have found to be an excellent means of distinguishing the pupæ of different species. For instance, the pupæ of Philonthus brunneus and of Philonthus longicornis are very similar in appearance, but the former has two divergent spines on the lateral margin of four abdominal segments and one on the next two, while the latter has a single spine on each of the six abdominal segments. The length of time that the pupal stage lasted depended on the weather as well as on the species, but usually it lasted from ten to twelve days. A day or two before the emergence of the adult, the pupa turned a mahogany brown. Then in the night the pupal skin broke and the adult appeared. At first it was but partially colored, but in a few hours it assumed its normal appearance.

SUMMARY.

In a period of about two months I raised twenty beetles from larvæ. In one instance the beetle was reared from the egg. The list includes eight Philonthus brunneus, (one of these was from the egg); four, Philonthus longicornis; one, Philonthus cyannipennis; one, Tachinus flavipennis; and five Belonuchus formosis. Several larvæ larger than any of these were found. One formed a pupa but died before it emerged. Probably this was Listotrophus cingulatus. The reasons for this belief are as follows: This is the only species of adult larger than Philonthus cyannipennis that was found, the larva is similar to the description of Listotrophus by Schaupp, and the pupa resembles the pupa of Listotrophus in the LeConte collection at Harvard.

Time. The length of time required for each stage of the life cycle is somewhat variable. An egg of Philonthus brunneus found August 9 hatched in four days. The larval stage lasted eleven days and the pupal stage thirteen days. In other cases the pupal stage lasted seven, ten, eleven, and twelve days. The pupal stage of *Belonuchus formosus* lasted nine and twelve days. The pupal stage of *Philonthus longicornis* was six, seven, nine and ten days. *Philonthus cyannipennis* took nine days.

TABLE OF STAPHYLINIDÆ RAISED.

Name	Larva Found	Becomes Quiet	Forms Pupa	Pupa Turns Dark	Emerges As Adult
Philonthus longicornis	July 10	.....	July 22	July 27	July 29
Philonthus longicornis	July 18	July 25	July 27	July 30	Aug. 2
Philonthus longicornis	July 18	July 25	July 27	Aug. 3	Aug. 5
Philonthus longicornis	July 25	July 29	July 30	Aug. 6	Aug. 9
Philonthus brunneus— Egg found Aug. 9; Egg hatched Aug. 13	.....	.....	Aug. 24	.....	Sept. 6
Philonthus brunneus	July 28	Aug. 1	Aug. 2	Aug. 11	Aug. 12
Philonthus brunneus	July 28	.....	Aug. 1	.....	Aug. 11
Philonthus brunneus	July 28	.....	July 30	Aug. 11	Aug. 12
Philonthus brunneus	July 16	July 22	July 23	July 29	July 30
Philonthus brunneus	Aug. 9	Aug. 13	Aug. 24	.....	Sept. 6
Philonthus brunneus	Aug. 16	.....	Aug. 23	Aug. 29	Sept. 2
Philonthus brunneus	Aug. 11	.....	Aug. 13	.....	Aug. 25
Philonthus cyannipennis	Ju.y 18	skin shed July 21	July 28	Aug. 5	Aug. 6
Belonuchus formosus	Aug. 9	.....	Aug. 20	.....	Sept. 1
Belonuchus formosus	Aug. 9	Aug. 11	Aug. 15	Aug. 23	Aug. 24
Belonuchus formosus	Aug. 12	.....	Aug. 23	.....	Sept. 1
Tachinus flavipennis	Aug. 13	.....	Aug. 18	.....	Aug. 24

Philonthus brunneus Grav. (Fig. I.)

Egg, (1 mm. in length). The egg was found August 9th in a rather dry mass of ground alder and touch-me-not. It is white in color and oval in shape, somewhat flattened at the ends. The surface is sculptured by dots thickly set in lengthwise striations. The egg breaks along these lines.

Larva.—The larva appeared four days later, August 13th. It is about 2.5 mm. in length. The head is reddish yellow and chitinized. The rest of the body is soft and white. It is very active and readily eats mites or small Dipterous larvæ. It grew rapidly and attained its full size in a few days. According to Xambeu it probably molts three times, but I was unable to discover any traces of these larval skins. Xambeu says that they eat the larval skin immediately. The full grown larva is a slender, active creature about 7 mm. long.

Head.—The subquadrate head is reddish brown and heavily chitinized. The mandibles are slender and sickle-shaped. The antennæ arise from the base of the mandibles. They are four-jointed. The first segment is short and broad; the second is longer and more slender; the third is similar to the second, but bulges toward the tip, where it has a small immovable joint on the inner side; the fourth segment is short and is tipped by several short hairs surrounded by three or four longer ones. The upper lip has seven teeth. The median one is very small. The first lateral pair is long, the next two lateral ones are considerably shorter and between them is a long hair arising from a distinct papilla.

Small hairs are seen between the other teeth. The first joint of the maxilla is short and broad, the second somewhat more slender and twice as long, with an additional lobe at the inner margin. The palpus is made up of five small segments. The labial palps have three segments.

Thorax.—The dorsal side of the thorax is covered with a reddish brown plate of chitin with several hairs scattered along its margin. The meso- and meta-thorax are half as long and are similar in appearance. The ventral side is white without any sign of chitin except a small triangular piece anterior to and between the first pair of legs.

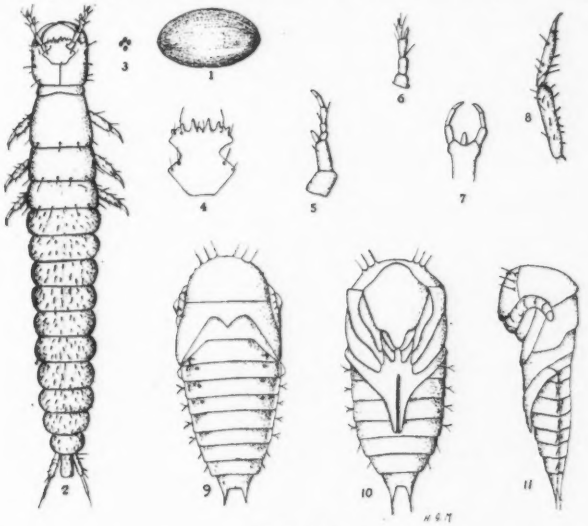


FIGURE I.

Fig. I. *Philonthus brunneus* Grav. 1, Egg. 2, Larva, dorsal view. 3, Ocelli. 4, Upper lip. 5, Maxilla. 6, Antenna. 7, Labium. 8, Leg. 9, Pupa, dorsal view. 10, Pupa, ventral view. 11, Pupa, lateral view.

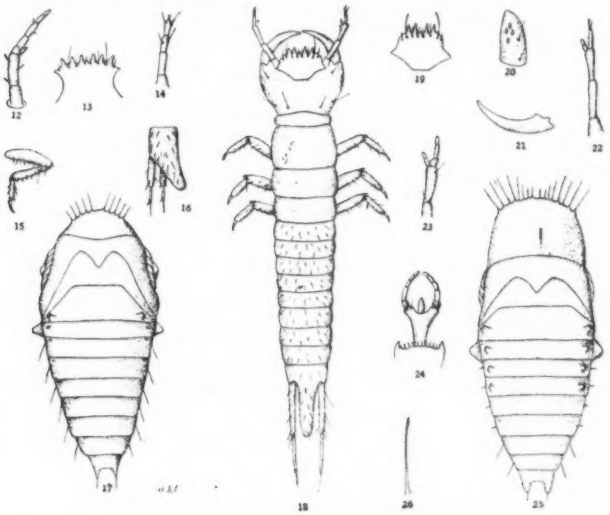
Abdomen.—The abdomen is a dirty white with short brown hairs scattered over its surface. It tapers toward the posterior end. The pseudopode is moderately long and thick. The anal styles are made up of two segments. The second is shorter than the first and is very slender. It is terminated by a long bristle. The styles are widely divergent. Both styles and pseudopode have hairs scattered over them.

Legs.—Small spines are scattered over the surface of the legs. The single claw on the tarsus is characteristic of all of the Staphylinidæ and is an easy way of distinguishing this family from the Carabidæ.

Pupa.—The pupa is 3.5 mm. long. There is a fringe of six hairs, three on each side at the anterior edge of the thorax. On the abdomen there are two divergent spines on the lateral margin of four segments and a single one on the last two segments before the terminal one, which ends in two projections, each tipped with a bristle.

Philonthus longicornis Steph. (Fig. II.)

Larva.—The larva of Philonthus longicornis is similar to that of Philonthus brunneus. In fact, it is difficult to find characteristics distinct enough to differentiate the two. The upper lip is the best character to use in this case. Both have an upper lip with seven teeth; in both the median one is very small and the first lateral pair is long, but in Philonthus longicornis the next lateral pair is practically the same size as the first, while in Philonthus brunneus it is distinctly smaller than the first lateral pair.



FIGURES II AND III.

Fig. II. *Philonthus longicornis* Steph. 12, Maxilla. 13, Upper lip. 14, Antenna. 15, Leg. 16, Pseudopode and anal styles. 17, Pupa, dorsal view.

Fig. III. *Philonthus cyannipennis* Fab. 18, Larva, dorsal view. 19, Upper lip. 20, Side of head showing ocelli. 21, Mandible. 22, Antenna. 23, Maxilla. 24, Labium. 25, Pupa, dorsal view. 26, Hair, from anterior margin of thorax.

Pupa.—The pupæ of Philonthus longicornis and Philonthus brunneus are easily distinguished. The former is some two mm. longer than the latter. Still more easily recognized are the hairs on the anterior margin of the thorax. On Philonthus longicornis there are five on each side, while on Philonthus brunneus there are three on each side. The bristles on the lateral margin of the abdominal segments are also distinctive. In Philonthus longicornis there are six bristles on each side, one on each segment. In Philonthus brunneus there are two divergent bristles on four segments and a single one on the next two segments.

Philonthus cyannipennis Fab. (Fig. III.)

Larva.—(Length 13 mm., width 2 mm.) The body is elongate and flattened.

Head.—The head is reddish and heavily chitinized. It is quadrate, wider than the thorax and with the posterior angles rounded. The mandibles are simple and sickle-shaped. The upper lip has five distinct teeth. The median one is small. The two lateral pairs are large. There is a short hair on either side of the median tooth and also between the lateral teeth and a long hair just beyond the lateral teeth. The lateral margin of the upper lip has two irregular projections not distinct enough to be called teeth. A short hair is found between these two projections. The antennæ are four-jointed. The first segment is short and broad. The second is three times as long and narrower. The third is twice as long as the first and narrow, with an additional lobe at the inner side. There are several long hairs near the tip. The fourth segment is short, ending in a group of long hairs. The first segment of the maxilla is short and conical. The second is long, with a short lobe of two immovable joints. The palpus is three-jointed. The ocelli are four, in two groups, three in one and one in the other. The labial palps have three segments.

Thorax.—The prothorax is dark reddish brown, slightly wider toward the posterior edge. The meso- and meta-thorax are equal in size, one-half as long as the prothorax and a lighter brown.

Abdomen.—The abdomen is a dirty white with short brown hairs irregularly scattered over it. The last segments become slightly longer. The pseudopode is barrel-shaped and longer than the last abdominal segment. The anal styles are set at an angle of 40° to the pseudopode and are set with many hairs. The second segment is long and slender and ends in a long bristle.

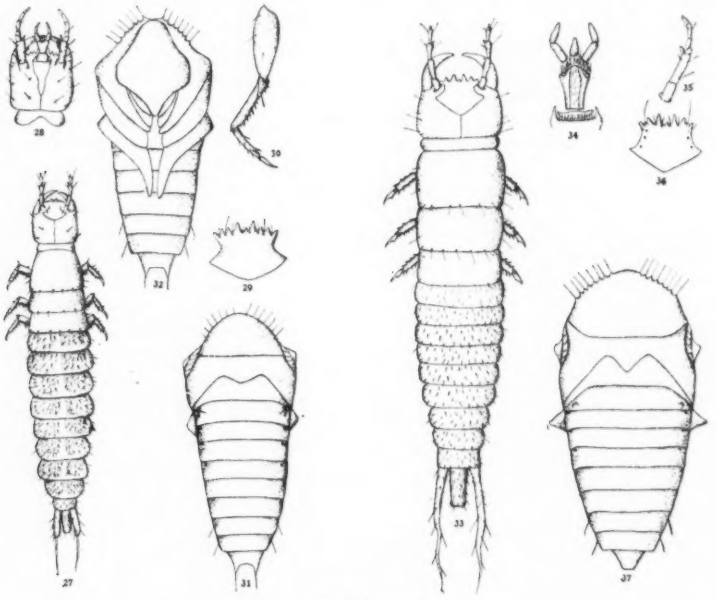
Pupa.—The pupa is in a case of yellowish brown chitin. There is a fringe of hairs, eight on each side, at the anterior margin of the thorax. There are six spines, four short and two long, on the lateral margin of the abdominal segments. The last abdominal segment ends in two more or less rounded projections terminating in a bristle.

Belonuchus formosus Grav. (Fig. IV.)

Larva.—(Length 7 mm., width 1.5 mm.) The body is elongate, slender and tapering. The head and thorax are reddish brown, the abdomen is a dirty white with gray patches on each segment. The gray region is divided by a broad median line. Short brown hairs are scattered over the body.

Head.—The head is quadrate, slightly broader than the thorax. The upper lip is nine toothed. The median tooth is very small, the first lateral pair is large, the next three lateral pairs are small. There are hairs between the teeth, all short except those between the second and third from the end, which are long. The mandibles are simple and

curved. The first segment of the maxilla is short and broad, the second is long and tapers toward the tip, with a small immovable joint at the inner edge. The palpus is four-jointed. The antennæ are four-jointed. The first segment is short and broad; the second is longer and slender; the third is the same length as the second and slightly broader, with a small lobe on the inner side; the fourth is short and slender, with two bristles surrounding a tuft of short hairs. There are four ocelli, three in one group and one somewhat posterior.



FIGURES IV ANE V.

Fig. IV. *Belonuchus formosus* Grav. 27, Larva, dorsal view. 28, Head, ventral view. 29, Upper lip. 30, Leg. 31, Pupa, dorsal view. 32, Pupa, ventral view.

Fig. V. *Listotrophus cingulatus* (?). 33, Larva, dorsal view. 34, Labium. 35, Maxilla. 36, Upper lip. 37, Pupa, dorsal view.

Pupa.—The pupa is a yellowish brown. There is a fringe of hairs, seven on each side, at the anterior edge of the thorax. There are lateral spines on the second and third last abdominal segments, each of which has one long spine on the lateral margin. The terminal segment has two projections ending in a bristle.

Tachinus flavipennis Dej. Fig. VI.)

Larva.—(Length, 7 mm.) This larva is linear, slightly depressed, and not as slender as most of the other forms studied. Instead of tapering toward the end of the body, there is a slight widening toward the posterior region. The color is distinctly brown. Each abdominal segment has two chitinized plates, one on the dorsal and one on the ventral side.

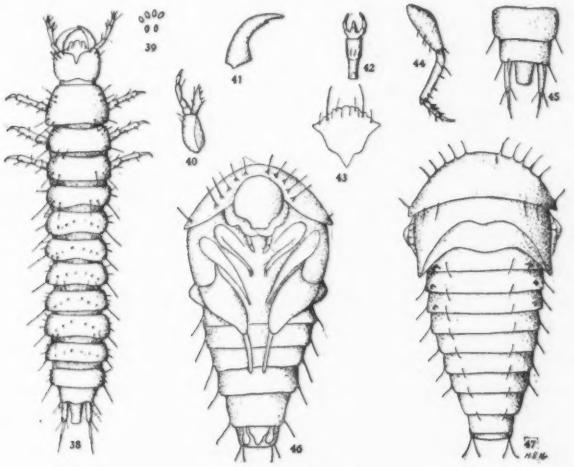


FIGURE VI.

Fig. VI. *Tachinus flavipennis* Dej. 38, Larva, dorsal view. 39, Ocelli. 40, Maxilla. 41, Mandible. 42, Labium. 43, Upper lip. 44, Leg. 45, Pseudopode and cerci. 46, Pupa, ventral view. 47, Pupa, dorsal view.

Head.—The head is oval and somewhat narrower than the thorax. The upper lip is without distinct teeth, but is divided into three regions. There are six ocelli arranged in two groups, four close together and the other two more separate and posterior to the group of four. The antennæ are made up of the following segments: The first segment is short and broad, the second is twice as long and somewhat more slender, the third is the same length as the second, becoming broader toward the tip and with an additional lobe on the inner side. There are two long hairs near the tip of this segment. The fourth segment is small and short with one long hair. The maxillæ are entirely different from those of Philonthus. There is a basal piece made up of two sclerites. Attached to this region are two parts. The inner one is rectangular, with a toothed edge like a comb on the inner side. The maxillary palpus makes the other region and consists of five slender segments. In the mentum and ligula is a squarish basal piece. The ligula is narrow at the base, broadens suddenly, and ends in a prolongation. The palpi are two-jointed.

Pupa.—The pupa is very different from any of the other Staphylinidæ under consideration. Instead of being thoroughly chitinized, it is covered with a soft substance which is pure white at first. When the box was uncovered, the light stimulus made it active and the posterior end would wave back and forth. Under the electric light the light or heat, or perhaps both, made it even more active than it was in the sunlight. This power of movement continued throughout the pupal period to some extent. As the days passed the pupa became a grayish white and the legs showed as dark patches through the thin covering. This covering when examined seemed silvery and glistening like fish scales. There is a fringe of twelve hairs, six on each side, at the anterior margin of the thorax. There is one bristle arising from the lateral margin of each abdominal segment and a double row of hairs nearer the center. The terminal segment is blunt and has four bristles.

CONCLUSION.

From these descriptions of a few larvæ and pupæ some generalizations are evident:

1. Staphylinidæ may be distinguished from the Carabidæ which they resemble in a general way by the following characters:

Carabidæ—	Staphylinidæ—
Inarticulate caudal styles	Biarticulate caudal styles
Two prongs on tarsus	Single prong on tarsus

2. All the Staphylinidæ are of the same general appearance and structure although there is considerable difference in size.

In the types studied, one belongs to the genus Tachinus, in the subfamily Tachyporinæ. The other five belong to the subfamily Staphylininæ in the following genera: one Listotrophus, one Belonuchus, and three Philonthus. Naturally Tachinus differs from the others in many respects. First, the shape of the larval body grows wider toward the end instead of tapering. Second, the chitinization of the abdominal segments differs, there being in Tachinus distinct chitinized plates on each dorsal and ventral abdominal segment. Third, the maxillæ are a distinctly different type as shown in the drawings. Fourth, the upper lip is not toothed.

There is a marked similarity among the Staphylininæ. The head and thorax are reddish brown and heavily chitinized. The abdomen is a dirty white. According to Xambeu there are three distinguishing characters, viz.:

1. Upper lip.
2. Antennæ and other appendages.
3. Pseudopode and anal styles.

I agree with him in thinking that the first is the most constant and definite character. The number and size of teeth are distinctive in each type studied. The antennæ and the maxillæ are so easily broken off that I should hardly call them good characters to use. The number of segments in the labial palpi, is variable. The pseudopode and anal styles or cerci vary somewhat in size but here again the differences are slight and hard to describe. One other character not noted by Xambeu I have found useful in distinguishing genera. That is the shape of the suture between the upper lip and the front. Notice the drawings of Belonuchus and Philonthus and at a glance the difference is apparent.

The characters of the pupæ are more distinctive than those of the larvæ. Tachinus has an entirely different covering of a scaly, silvery substance. The Staphylininæ all have a covering of yellowish brown chitin and although differing in size, have the same general shape and appearance. They do vary, however, in two respects. First, the number of hairs on the anterior margin of the thorax differs with each species studied. Second, the form and number of the bristles on the lateral margin of the abdominal segments varies with the species. By using these two characters it is comparatively easy to name the species from the pupæ.

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THE LIFE HISTORY AND HABITS OF BICYRTES QUADRIFASCIATA SAY.

(Order Hymenoptera, Family Bembicidæ).

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The wasp which is the subject of this paper is a member of the family *Bembicidæ*, a family of solitary digger wasps. The family *Bembicidæ* is divided into two tribes, the *Stizini* and the *Bembicini*, to the latter of which *Bicyrtes quadrifasciata* belongs. Wasps of this tribe are of a large robust striking appearance. The ground color of these wasps is black, on top of which lies stripes or spots of light yellow or yellow. The wings may be hyaline or infuscated and the body may be thickly pilose or more or less free from this. According to Parker: "The most prominent characters distinguishing the *Bembicine* wasps are the non-folded wings lying flat on the back, the three closed cubital cells of the anterior wings, of which cells the second receives both discoidal cross veins, the absence of the prepectus, the prominently exserted labrum and the lack of developed ocelli." The individuals are males and females. The female constructs her nest alone in sandy areas and provides for her offspring; nests are often placed so closely together that the wasps may be said to form colonies. There is considerable diversity in the selection of food for their young, some species feeding them on flies, some on the nymphs of true bugs, while still others feed their young on insects of various orders and families.

Bicyrtes quadrifasciata is a very common and striking species and is recorded by Parker as occurring in Florida, Georgia, Alabama, South Carolina, Virginia, Pennsylvania, New Jersey, New York, Connecticut, Indiana, Ohio, Wisconsin, Kansas, and New Mexico. Mickel reports it from Nebraska, the Raus from Missouri, and the writer has taken it in North Carolina and Mississippi.

One day during the latter part of July, 1922, while the writer was engaged in general scouting he was fortunate enough to run upon the nesting site of this interesting species of wasp.

Previous to this time no thought had been given to a study of the life history or habits of *Bicyrtes quadrifasciata*. Literature reviewed on the subject contained only fragmentary notes; in view of these facts the writer thought it worth while to undertake a study of this species, the results of which are given in this paper.

The writer is very grateful to Professor R. W. Harned for encouragement given in the prosecution of this study and for the generous allotment of time. The writer is also indebted to Dr. C. J. Drake for the determinations of the food of the young wasps, to Mr. H. W. Allen for the determinations of the flies mentioned herein, and to Mr. J. M. Langston for his kind assistance in looking after the breeding material during the writer's absence from the office on Argentine ant work.

As mentioned above in this article the writer's attention was first attracted to these wasps during a day in the latter part of July, 1922, while walking along a public road near Adaton, Mississippi. On each side of the road for a distance of about two hundred yards was a strip of sand, which in no place was over a foot and a half in depth. The wasps were noticed flying over this strip of sand in a manner that betokened they were interested in something there. One particular wasp was observed flying over the sand as if she intended to light when she became satisfied that all was well. After hovering for a few minutes over a certain spot she finally settled on the ground and began to dig very vigorously with her front feet, throwing the sand backward through the space between her middle and hind feet, the two pairs of which formed a brace for the body. The sand came out in stream like spurts landing anywhere from six to eighteen inches from her. After digging very strenuously for a few seconds she succeeded in opening the gallery to her nest, entered and was lost to view. In a minute or less she emerged, and the writer, being anxious to discover what she was doing, drove her away and began to excavate the soil about the nest with a trowel.

The earth was sliced off bit by bit with care and the gallery of her nest traced to its terminus. The gallery or hole led from the surface of the soil to a depth of about six inches where it ended abruptly in an enlarged pocket in which were found several nymphs belonging to the families *Pentatomidæ*, *Coreidæ* and *Reduviidæ*. These nymphs, representing different stages of

development were lying flat on their backs in a perfect state of paralysis. Each nymph appeared fresh and lifelike except that it was incapable of locomotion and even when prodded with a pin would only respond by feebly moving its antennæ and legs.

After carefully examining each nymph for the egg of the wasp which was expected to be on one of them, the writer at last succeeded in finding an egg on a very large nymph. The egg was elongate, curved, and tapered from the posterior to the anterior end. In color it was a dull or opaque yellowish white. The blunt or posterior end of the egg was attached to the nymph in the space between the coxæ of the middle legs. The anterior portion or head of the egg projected from the body of the nymph towards the nymph's head. For a long time the writer was puzzled as to why the posterior portion of the egg should be attached to the nymph and not the anterior. It seemed that the reverse would be the ideal arrangement since the little waspling would upon hatching find food immediately at hand and thus be secured from any chance of starving while in a weak and helpless state. It was only after the life history was started that the writer became enlightened on this point. One day while examining the life history cages the writer was fortunate enough to find a larva attempting to eat its first meal. This was one of the most interesting observations made during the life history work and when the observation was completed the writer could not help but marvel at the adaptation. The young waspling upon hatching was of course very hungry and immediately began to search for food. After many minutes of exertion, throwing its head from side to side, it at last located the beak of the nymph and inserted its mandibles into the thin tissue separating two joints of the beak and began to imbibe the body fluid. As the fluid was pumped away from the nymph, the larva's stomach could be seen pulsating, and after several hours the fluid of the nymph began gradually to tinge the larva a greenish color. The appetite of the larva at this stage is voracious and it feeds continuously. One can almost see it grow so fast is its development. From a small microscopic worm at the time of hatching it grows rapidly and usually at the end of from three to five days is ready for pupation. In the life history work the egg and larval stages are passed in a remarkbaly short time. After having fed on the fluid of the nymph for several hours the larva becomes strong enough to pierce any part of the chitin of

the nymph and will feed on any part of the nymph's body that proves attractive to it. As far as could be determined no preference was shown for one part of the nymph's body over another. No doubt the size of the future wasp is determined by the number and size of the various nymphs placed in the nest by the mother wasp. In the life history work where only a few small nymphs were fed to a larva, in every case it developed into a small, undersized wasp while those that had plenty of food developed into well formed wasps of the average size. Without doubt the nests in the field are well provisioned by the mother wasp when she or her nest is left undisturbed. The usual number of nymphs found in a nest varied from six to eleven but nests were found during the course of study that contained only one to three nymphs. It is the writer's opinion that these nests were incomplete but it is impossible to be sure of this fact, as the mother wasp has a habit of sealing her nest on leaving for the field although that nest may still be in the process of provisioning.

One wasp was very carefully observed while digging her nest. She flew over the sand in a certain locality for several minutes, finally to light on the ground and walk over it in a very hesitant manner as if undecided where to construct her nest. After examining many cracks and crevices she at last selected a certain spot and began to dig. In this operation her head was lowered and her front feet and mandibles called into play. Her back feet, aided by the middle feet, formed a brace for the body during this work. By using her mandibles she loosened the dirt in front of her, which was kicked vigorously back out of the way by her front feet. As she worked she emitted a low humming sound which seems to be common to many of the sand digging wasps with which the writer is acquainted. In digging she would rotate her body from side to side as the operation required but she was never observed lying flat on her back during this excavating work. By continually rotating her body she kept the gallery of her nest of a more uniform diameter than she would have been able to do otherwise. After she had dug for seven minutes the writer estimated that she had proceeded about an inch. One would think that the strenuous operation of digging would tire her, but apparently not, for she kept at the work rather persistently, occasionally leaving the nest to take a few short flights after which she

would return to the nest and dig as vigorously as ever. These flights may have been due to disturbance by the writer for it was necessary that he get very close to the nest in order to make these observations. When she had excavated a few inches and was out of sight she would occasionally back up almost to the surface, where a pile of dirt had accumulated behind her and was threatening to block the gallery of the nest, and with much strength and vigor kick this out until the gallery was again free from obstructing dirt. Upon finishing this she would go below and excavate again until the dirt once more threatened to block the gallery, when she would stop and repeat the performance described above. These performances were repeated alternately until the nest was completed. After digging for an hour she came to the surface and walked around the nest for a few seconds as if looking for any faults in construction; then apparently being satisfied with her workmanship she began kicking dirt into the entrance to the gallery. While engaged in this she faced away from the nest but was close enough to the entrance so that each spurt of dirt would fall exactly into the right spot. After kicking dirt a moment from one spot she would move to another and repeat the operation, thus completely circling the nest by the time she had finished. Upon filling the entrance hole, she crawled on top of the dirt that lay there, and with her abdomen bent forward under her used the dorsal side of it in packing the dirt firmly into the gallery to form a plug. This being finished in short while she walked over the nest carefully scratching the dirt here and there that it might not leave any tell-tale trace. Satisfying herself on this point she took to the air flying in larger and larger circles until she finally disappeared. Mr. Allen and the writer timed her to see how long she would be gone from the nest, but after waiting three-quarters of an hour without success we gave her up because of the swiftly approaching dusk. We failed to learn whether she was successful in the quest of food for her future young or whether she had decided to take the evening off after so strenuous a day.

The fact that this wasp closed her nest before leaving it seems to indicate that this must be an hereditary point with them, for it seems impossible to conceive that the *Senotainia* flies which pester their nests would deposit maggots in a nest that did not contain the wasplings or their food. A number

of other wasp nests, which were closed at the entrance, similar to this one, when opened were found to be bare of nymphs or immature wasps. These observations show that the wasps close their nests before leaving them whether they are provisioned or not, though not invariably, for the writer has found nests which were open at the entrance and contained the immature forms of the wasps and their food, or were bare of either. No doubt it is the habit of the wasp to close their nests on leaving them whether empty or not and the instances just cited were most probably oversights on the part of the wasps.

The plug of dirt which closes the entrance to the nest is usually about the diameter of a pencil or slightly larger and is an inch in length or longer. Beneath this plug the gallery is free of any obstruction as is also the pocket or terminal, in which the wasp's life history is passed. One can stand directly over the nests and unless he keeps his eyes glued to the spot will lose their location so well are they concealed. The wasps, however, upon returning from the field seldom have trouble in locating their nests, although occasionally one apparently loses her nest and searches here and there for it in a state of nervous excitement. It is quite probable that most of this trouble is due to the fact that the nests are disturbed by passing teams, cars, etc., during the wasp's absence in the field.

All the nests the writer has seen were constructed in sand, possibly because sand is so much more easily excavated than other types of soil. A gallery about the diameter of a pencil or a little larger and from six to eight inches in length leads from the surface of the soil to a terminal pocket in which live the waspling with its food. The pocket is larger in diameter than the gallery that leads to it, is about two inches long and of an oval shape. The gallery may be straight or somewhat winding and connects with the surface of the soil at an angle of about forty-five degrees. The gallery is never obstructed or plugged except at the entrance to the nest.

The wasp when returning to the nest from the field with her prey usually flies in gradually diminishing circles over the nest before lighting. Even before she alights one can see the nymph which she clutches to her with the ventral side up. Upon alighting she locates the exact entrance to her nest and begins to dig, all the while holding her prey with the middle legs, while she excavates with her front feet. On no condition does she

lay her prey aside while opening her nest as the very wary little *Senotainia* fly is usually at her heels probably looking for such an opportunity. Usually after a minute of vigorous digging the wasp has removed the plug from her nest and is ready to enter.

Nine species of *Heteroptera* were found stored in the nests of these wasps. These species belonged to three different families. The species of nymphs found in the nests were as follows:

Pentatomidæ: *Acrosternum hilaris* Say., *Brochymæna quadripustulata* Fabr., *Euschistus* sp.

Coreidæ: *Archimerus calcarator* Fabr., *Leptoglossus phyllopus* Linn., *Chariestrus antennator* Fabr., *Acanthocephala femorata* Fabr.

Reduviidæ: *Zelus* sp. and *Apiomerus* sp.

The nymphs were of various sizes and stages, those of the leaf footed plant bug and the green soldier bug being most common.

In studying the life history of this wasp the contents of each nest were removed from the field to separate tin salve boxes which contained moist sand similar to that surrounding the nests. These boxes were kept in the office of the writer and were examined from day to day, each important change being recorded. The egg and larval stages were passed in a very surprisingly short time, the pupal stage occupied much more time than was expected, and for some time doubt was entertained as to whether the wasps would emerge successfully from this stage or not. For convenience the writer has tabulated the lengths of the various stages of each wasp and this data is shown in a chart following a general discussion of the insect's life history.

From the tabulated life history given below it can be seen that the minimum period in which this wasp has gone from egg to adult was 27 days, the maximum period being 44 days with a computed average of about 33 days. The egg stage occupies from 1 to 3 days with 2 days as a probable average; the larval period from 3 to 14 days with 6 days as a computed average, and the pupal stage from 15 to 40 days with 25 days as the average. No attempt was made to determine the number of generations per year as the wasps were not observed until late July, and from the first of August until late in November the writer was away from the office on business. Mr. Allen, who visited the nesting site of the wasps during the middle of August reported no signs of life present. It is not known whether the wasps had given up this site because of the frequent

disturbances or whether they left because their breeding operations for the year were completed. During these studies it was noticed that the wasps showed a fondness for sunlight and were rather inactive on cloudy or cool days. It may be assumed from this that the height of their breeding season is probably during July and August, the two hottest months of the year, and when there is plenty of sunlight available for their activities.

TABULATED STATEMENT OF THE LIFE HISTORY WORK.

Experiment No.	Days in Egg Stage	Days in Larval Stage	Days in Pupal Stage	Total Days	Remarks
1	1	5	28	34	
2	2	14	15	31	
3	2	10	15	27	Pupa never completely encased
4	1	4	24	29	
5	3	3	26	32	
6	1	3	..	..	Failed to emerge from cocoon
7	1	7	..	..	Died before encasing
8	1	5	..	..	Failed to emerge
9	1	3	40	44	
10	1	..	..	..	Larva died
11	..	..	..	..	Egg lost
12	?	?	24	..	Egg hatched, cocoon spun unobserved
13	?	?	27	..	Egg hatched, cocoon spun unobserved

While the wasps are storing their nests very small greyish flies hover above and to the rear of the wasps, or else sit on stones, blades of grass, or sticks near by, intently watching

every move of the wasps and looking for a chance to deposit maggots in their nests. The flies are ordinarily very wary and hard to capture, but so intent do they become in watching the wasps that one can capture them with little difficulty. The only opportunity they seem to have for depositing maggots in the nest is when the wasp is storing food for her young, as at other times the nest is closed by the plug at the entrance, and the wasp never lays her prey aside while engaged in opening the nest entrance. The writer has seen a fly dart into the nest immediately in the rear of the wasp, remaining below only three or four seconds to reappear again in a very hurried manner at the surface. The fly undoubtedly must have the ability of larvipositing in a very short length of time since it was observed to remain below but a few seconds at the most. Mr. Allen, who is interested in the biology and taxonomy of the genus *Senotainia* and allied groups, determined the flies captured in the vicinity of the wasps' nests as a species which he feels most certain to be *S. trilineata* V. d. W. and another possibly identical with *rubriventris* of Macquart. but more likely a distinct species. Maggots taken from the nest of these wasps by the writer and Mr. Allen and reared to maturity by the latter proved to be of the same species as the adults captured in the vicinity of the nests. According to Mr. Allen, the maggots live first as parasites of the paralyzed nymphs, later as scavengers on their decaying bodies, incidentally destroying the larva of the wasp for whom the provisions were so laboriously accumulated.

NOTES ON AMERICAN BACTRODINÆ AND SAICINÆ (Heteroptera: Reduviidæ).

By W. L. McAtee and J. R. Malloch.

These notes have resulted almost incidentally from a more comprehensive study we have made of the American Ploiariinae, but they assemble more information than has hitherto been available on these sub-families, hence we trust will be useful.

Subfamily Bactrodinæ.

The presence of ocelli readily distinguishes this subfamily from Ploiariinæ and Saicinæ; in addition to this character the presence of but one closed cell in apical half of hemelytra (Fig. 1), elongated coxæ, and spinose trochanters, femora, and tibiæ of the fore legs, position of head, which is apparently inserted on anterior portion of the dorsum of pronotum, and the structure of the tarsal claws, distinguishes them from any allied subfamily. The structure of the claws is peculiar; both are present, one very large, with a basal tooth about half as long as the main part, and the other about as large as this basal tooth. Like the fore tarsi, the mid and hind pairs are three-segmented, but the apical segment is slightly swollen and has a short stout spine near middle on the ventral surface, which lies against one side of the large claw when this is flexed back along the venter of the segment.

Only one genus, Bactrodes, is known, a key to the species of which is given below.

Genus **Bactrodes** Stal.

Key to the Species.

1. Fore femur with three fuscous annuli on distal half; antennæ and mid and hind legs each with several fuscous annuli ..... *multiannulatus* Berg.
   Fore femur with two fuscous annuli on distal half; antennæ and mid and hind legs with fewer fuscous annuli, usually one to the segment 2
2. Head and pronotum with numerous spines ..... *spinulosus* Stal.
   Head and pronotum with few or no spines 3
3. A sharp anteriorly curved tubercle or spine behind each antennal insertion. ..... *femoratus* Fabricius.
   No such spine present ..... *biannulatus* Stal.

List of the Species.

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B. spinulosus Stal, C. Hem. Mex., Ent. Zeit. Stettin, 23, 1862, p. 442 [Mexico]. Other locality, Guatemala (Champion).

B. femoratus Fabricius, J. C., Syst. Rhyng., 1803, p. 291 [Middle America]. Specimens examined: Paraiso, Canal Zone, Jan. 2, April 7, 1911, E. A. Schwarz (U. S. N. M.); Nord Capite de St. Paul; Jatahy, Prov. Goyaz, Brazil, 1904, H. Donckier (Paris Mus.).

B. biannulatus Stal, C. Rio Janeiro Hem. 1882, p. 80 [Rio Janeiro; this species monotype of the genus described at this reference]. Other localities, Panama, Mexico (Champion). Specimens examined: Portobello, Panama, Feb. 19, March 2, April 18, 1911, A. Busck (U. S. N. M.); Jatahy, Prov. Goyaz, Brazil, 1904, H. Donckier (Paris Mus.).

Subfamily Saicinæ.

The American forms of this subfamily examined by us agree (aside from ordinal and family characters) in lacking ocelli, in having the fore coxæ usually more or less elongate, the second segment of beak more or less bulbously expanded basally, the opposed surfaces of beak and head armed with stiff hairs, a few spine-like bristles, or spines, and the lower anterior angle of pronotum, just above coxal cavity, produced and surmounted (except in Oncerotrachelus) by an anteriorly and downwardly directed spine or bristle.

Key to the Genera.

1. Mesonotum with a long triangular process terminating in a depressed spine extending over the metanotum and basal abdominal tergite, which lack dorsal protuberances; a conspicuous spine on each side of the basal tergite projects outward, appearing to emanate from hind angle of metapleurum; basal tarsal segment shorter than third and not longer than second; venation of forewing as in Figure 2; fore femur and tibiæ without spines, armed with erect stiff hairs only; opposed surfaces of beak and bead with rows of stubby bristles.....*Oncerotrachelus* Stal.

   Mesonotum not produced posteriorly, metanotum and basal abdominal tergite with dorsal tubercles or spines; no spine on side of basal tergite; basal segment of all tarsi longest; opposed surfaces of beak and head with distinct spines or spine-like bristles.....2

2. Fore tibia, and femur, in part, with stiff, erect hairs, without stout spines; venation of fore wings as in Figures 5 and 7; pronotum, mesonotum, and basal abdominal tergite each with a prominent spine.....*Saica* Stal.

   Fore tibia with one, fore femur with two series of stout spines; venation of fore wing as in Figures 10 and 13.....3

3. Mesonotum, metanotum, and basal abdominal tergite each with an apical tubercle; a long, sharp, outstanding spine on each side of posterior lobe of pronotum near hind angle; no curved carina on side of anterior lobe of pronotum; a short spine beneath each antennal insertion; fore coxæ short, unarmed; fore wings spotted.....*Bagriella* new genus

   Mesonotum and basal abdominal tergite each with a long spine, metanotum with a tubercle; no spines on posterior lobe of pronotum; an arcuate carina extending posteriorly from a low rounded tubercle on front edge of side of anterior lobe of pronotum; no spines beneath antennal insertions; fore coxæ elongate, each armed with a dorsal bristle; fore wings unicolorous.....*Tagalis* Stal.

Genus **Oncerotrachelus** Stal.

In addition to the characters listed in the key to genera, this genus has very distinct hairs on the upper side of basal section of the radius of fore wings, the thoracic mesosternum and metasternum with a central carina, and the ventral surface of head and beak with rather dense stubby hairs, which are not arranged in tufts. The coxæ of fore legs are three or four times as long as thick, finely haired, and have two outstanding long fine hairs on anterior side; in the two tropical species there is a slight hump on the inner side, which is not visible when the coxa is pressed against the prosternum. Front femora slightly curved. Color testaceous, rather strongly marked with fuscous except in one species (*pallidus*).

Pleurosigynius Berg. (Hem. Arg. 1879, pp. 178-179) apparently is a synonym of *Oncerotrachelus;* whether its only species, *lynchii*, described from the Province of Buenos Aires, is different from the others here included we are unable to say.

KEY TO THE SPECIES.

1. Each posterior lateral angle of pronotum produced into a conspicuous sharp spike; median longitudinal impression of pronotum relatively broad, and rather coarsely transversely striate in bottom on anterior part of hind lobe; fore coxa as in next species; central carina of mesonotal process obsolete. ..... *conformis* Uhler
   Posterior lateral angles of pronotum without sharp spikes; median longitudinal impression of pronotum linear and not appreciably striate; central carina of mesonotal process distinct 2
2. Fore coxa with a slight but distinct angulate elevation about one-third from apex below, usually with a wax-like excretion attached to apex of elevation and projecting toward apex of coxa (Fig. 3) ..... *coxatus* new species
   Fore coxa without a distinct elevation as above (Fig. 4) 3
3. Hairs on tibiæ decumbent, not longer than the tibial diameter; larger species 7-7.5 mm. in length, paler in color; posterior lateral angles of abdominal tergites not appreciably produced ..... *pallidus* Barber
   Hairs on tibiæ in part erect and very conspicuously longer than tibial diameter on at least the mid and hind legs; smaller species, 4-6 mm. in length, darker in color; posterior lateral angles of most of the abdominal tergites more or less produced and spine-like ..... *acuminatus* Say.

LIST OF THE SPECIES.

O. conformis Uhler, P. R., Het. Grenada, Proc. Zool. Soc. Lond. 1894, p. 211 [Grenada]. Specimens examined: Balthazar, Grenada, H. H. Smith; Tabernillo, Canal Zone, June 8, 1907; Trinidad River, Panama, May 2, 3, 8, 1911; Alhajuelo, Canal Zone, May 27, 1912, A. Busck. (U. S. N. M.).

O. coxatus new species. In this uniformly colored genus no description of this species besides that given in key, seems necessary. Length, 5.5–6 mm. Holotype ♂, Trinidad River, Panama, May 3, 1911; allotype ♀, same locality, May 9, 1911; paratypes, May 2, 4, 1911, June 4, 1912; all collected by Aug. Busck; Cacao Trece Aguas, Guatemala, E. A. Schwarz and H. S. Barber, (U. S. N. M.); Igaraba Assa, Brazil, 1912 (Bueno).

O. pallidus Barber, H. G. Proc. Ent. Soc. Wash., 24, No. 4, April, 1922, p. 104 [Texas]. Only one specimen in addition to original material seen, that labelled simply Texas (U. S. N. M.).

O. acuminatus Say, Thomas. Desc. New Sp. Het. 1831, Compl. Writings 1, p. 356 [Indiana]. Made the type of the new genus Oncerotrachelus by Stal (Hem. Fabriciana, 1, 1868, p. 130). The distribution of this species as stated in the past comprised more or less of that of all of the preceding species. Specimens we have examined come from a range having the following states at its extremes: New York, Indiana, Kansas, Texas and Florida.

Genus **Saica** Stal.

Beak with one pair and head with two pairs of spines on their opposed surfaces; fore coxa with one and fore trochanters with two patches of stubby bristles; fore femur with two rows of bristles of uniform length, the degree of aggregation of which into tufts is fortuitous and has no taxonomic significance; front femora and tibiæ distinctly curved; species chiefly reddish in color with ochraceus, red-veined fore wings, most of them distinctly larger than species of the other American genera. Venation as shown in Fig. 5.

Key to the Species.

1. Fore wing with three completely closed discal cells (Fig. 5); posterior pronotal spines short, divergent, acute; mesonotal spine relatively short, acute; metanotal process expanded and broadly emarginate (but not so pronouncedly developed as in *rubripes*); spine on first tergite rather stout, almost angularly upcurved, and acute apically; spines on hind margin of male hypopygium well separated at base, upright for the basal third of their length, then diverging outwardly, the apices with a small barb on outer side (Fig. 9); second antennal segment at least one-half as long as first and 1.5 as long as fourth..... .....*apicalis* Osborn and Drake

   Fore wing with only two completely closed discal cells.....2

2. No nearly closed discal cell basad of the two closed cells; apex of outer discal cell not attaining to level of apex of stigma (Fig. 7); spines on lower anterior angles of prothorax rounded and blunt at apices; dorsal spines on posterior pronotal lobe long and acute; genital plate of female directed strongly anteriorly (in all other species it is approximately vertical); general color testaceous, each femur with a subapical, and each tibia with a sub-basal fuscous annulus, a dark streak above over head, thorax and fore wings; abdomen marked moderately beneath and heavily above with fuscous; second antennal segment a little over one-third as long as first and noticeably shorter than fourth.....*fuscovittata* Barber

   A nearly closed discal cell basad of the inner one; spines on lower anterior angles of prothorax long and acute; second antennal segment rarely less than half as long as first and always longer than fourth.....3

3. The apex of outer discal cell falls distinctly short of end of stigma; abdomen slender and more narrowed basally than in the other species; dorsal spines long and acute; spines on hind margin of male hypopygium directed strongly laterad and slightly upward; general color stramineous, bases of pronotal spines, subapical bands on femora, stigma and veins at base of fore wings (in part) red; membranous parts of fore wing with more or less dusky clouding. .....*erubescens* Champion

   The apex of outer discal cell extends as far as apex of stigma; abdomen less slender and narrowed basally.....4

4. Metanotal process inverted scoop-shaped, and deeply emarginate; mesonotal spine long, that of basal tergite moderate; pronotal spines long; general color pale orange red, legs without bands, wing veins red...*rubripes* Champion
Metanotal process more or less arcuate laterally and notched but not expanded as in *rubripes*.....5
5. Spines of hind margin of male hypopygium without a deep rounded emargination between their bases, directed more strongly laterad than upward (Fig. 8); dorsal spines moderately long and acute; general color pale red, coxæ, trochanters, tibiæ (except at bases), antennæ chiefly, and fore wings pale ochraceous, stigma and veins a little deeper colored.....*tibialis* Stal.
Spines of hind margin of male hypopygium separated basally by a deep rounded emargination, directed strongly upward as well as laterad (Fig. 6); femora and distal portions of legs and antennæ dusky to fuscous; head, thorax, coxæ and trochanters red; fore wings ochraceous, the veins more or less reddish...6
6. Dorsal spines well developed.....*recurvata* subspecies *recurvata* Fabricius
Dorsal spines shorter, blunt in the female.....
.....*recurvata* subspecies *antillarum* new subspecies,

List of the Species.

S. apicalis Osborn, H., and Drake, Carl J. Ohio Nat., 15, 1915, p. 530 [Guatemala]. Specimens examined: Trinidad River, Panama, June 2, 1912, A. Busck; Ancon, Canal Zone, C. P. Crafts; Cayuga, Guatemala, Nov., 1915, W. Schaus. (U. S. N. M.).

S. fuscovittata Barber, H. G. Hem. Florida, Bul. Am. Mus. Nat. Hist. 33, 1914, pp. 504-505 [Florida]. Only the allotype examined.

S. rubripes Champion, G. C. Biol. Centr. Amer. Het. 2, 1898, pp. 177-178 [Panama, Colombia]. Specimens examined: Cayamas, Cuba, May 20, E. A. Schwarz; Cuba. (U. S. N. M.(.

S. erubescens Champion, G. C., Biol. Centr. Amer., Het. 2, 1898, p. 178 [Panama]. Specimens examined: Cacao Trece Aguas, Guatemala, April 9, E. A. Schwarz and H. S. Barber; Piedras Negras, Costa Rica, Schild and Burgdorf. (U. S. N. M.).

S. tibialis Stal, C., Hem. Mex., Ent. Zeit. Stettin, 23, 1862, pp. 441-442 [Mexico]. Other localities, Guatemala, Panama (Champion). Specimens examined: Chiapas, Mex., L. Hotzen; Atenas, Costa Rica, Schild and Burgdorf. (U. S. N. M.).

S. recurvata recurvata Fabricius, J. C., Syst. Rhyng., 1803, p. 286, [Middle America]. *S. rubella* Amyot and Serville, Hist. Nat. Ins. Hem., 1843, p. 372, from Guiana is regarded as a synonym. Other localities, Mexico, Guatemala, Panama, Colombia (Champion). Specimens examined: Cacao, Trece Aguas, Guatemala, March 24, 1906, E. A. Schwarz and H. S. Barber; Tumupasa, Bolivia, December, W. M. Mann; Demerara. (U. S. N. M.).

S. recurvata antillarum new subspecies. Sufficiently described in key. Length, 12 mm. Holotype ♂, St. Vincent, West Indies, H. H. Smith; allotype ♀, Balthazar, Grenada, West Indies, H. H. Smith. (U. S. N. M.).

In addition to the forms mentioned above, we have seen a damaged specimen (U. S. N. M.) of a smaller and distinct species from Texas.

DESCRIBED SPECIES NOT SEEN.

S. cruentata Bergroth, E., Ann. Soc. Ent. Belg., 52, 1913, pp. 234-235 [French Guiana].

S. fuscipes Stal, C. Hem. Mex., Ent. Zeit. Stettin, 23, 1862, p. 441 [Mexico]. Other locality, Guatemala (Champion).

S. ochracea Distant, W. L. Ann. Mag. Nat. Hist. Ser. 7, X, 1902, p. 175 [Ecuador].

Genus **Tagalis** Stal.

Tagalis Stal, C. Bidrag till Rio Janeiro Traktens Hemipter-Fauna, Pt. 1, 1862, p. 76. [Monobasic, *T. inornata* n. sp., genotype.]

Characters of significance common to all the species examined are: Tylus more or less tuberculate apically; eyes prominent; basal segment of beak nearly equal in length to apical two segments together; basal segment of antenna about four-fifths as long as the remaining three together; prothorax rather strongly constricted at about the middle, the anterior lobe with two rather prominent rounded dorsal swellings anteriorly, and two less prominent ones posteriorly; the mesonotum and basal abdominal tergite each with a single spine and the metanotum with a tubercle; fore femora and tibia each a little curved, the former with a series of five or six, and the latter with three, strong, curved spines on antero-dorsal surface; fore coxa moderately elongate, with an erect dorsal bristle, and two or three shorter ones on postero-ventral surface; fore trochanters with a few bristles beneath; hind legs considerably longer than middle ones, the femora of both pairs slightly clavate; fore wings membranous, with two discal cells; as in Saica, the radius is bare. Venation as shown in Fig. 10.

The length of spines on fore femora varies sexually and to some extent individually, and therefore does not seem of taxonomic import.

KEY TO THE SPECIES.

1. Thorax chiefly fuscous, the femora also fuscous or at least with the apices fuscous.....*seminigra* Champion
   Thorax chiefly testaceous, the femora with only a subapical annulus fuscous..2
2. Median spine of male hypopygium projecting distinctly beyond claspers (as it does also in preceding species, Fig. 12); first segment of antenna without subbasal fuscous markings; larger, 5½–6½ mm..*inornata* subsp. *inornata* Stal.
   Median spine of male hypopygium projecting little if any beyond claspers (Fig. 11); first segment of antenna with traces at least of sub-basal fuscous markings; smaller 5–5½ mm....*inornata* subsp. *cubensis* new subspecies

LIST OF THE SPECIES.

T. seminigra Champion, G. C. Biol. Centr. Amer. Het. 2, 1898, pp. 179-180, Pl. 11, Fig. 7.. [Panama]. Specimens examined: Trinidad River, Panama, May 6, 1911, A. Busck; on orchids from Venezuela, collected at quarantine, New York City, (U. S. N. M.); Mallali, British Guiana, H. S. Parish (Bueno).

T. inornata inornata Stal, C., Rio Janeiro, Hem. 1, 1862, p. 76, [Rio de Janeiro; monotype of the new genus described at this reference]. Other localities, Mexico, Guatemala, Panama (Champion). Specimens examined: Cordoba, Mex., March 30, 1900, May 16, June 13, F. Knab; Livingston, Guatemala, May 12; Cacao Trece Aguas, Guatemala, April 19, 26, 27, E. A. Schwarz and H. S. Barber; Tempisque, Costa Rica, January 20, 1921, A. Alfaro; Portobello, Panama, March 13, 1911, A. Busck; Senahu, Vera Paz, Champion, (U. S. N. M.).

T. inornata cubensis new subspecies. Description further than given in key seems unnecessary. The holotype ♂, allotype ♀, and paratype ♂ and ♀, are from Cayamas, Cuba, February 5, E. A. Schwarz; another paratype same locality and collector, January 1, (U. S. N. M.). The *Saicodes annulatus* Uhler (Check-List, 1886, p. 26, "Western States," the real locality Cuba, original specimen, now much damaged, U. S. N. M.) belongs here, and *Saica annulipes* (Uhler, P. R., Het. Grenada, Proc. Zool. Soc. 1894, pp. 210-211 [Grenada]), probably is the same. Certainly this latter insect is not a *Saica* and almost certainly it is a *Tagalis*. The description tallies with the form here described in all but two characters of any moment; if the suggested synonymy holds Uhler's name will of course replace ours.

Genus **Bagriella** new genus.

Agrees with *Tagalis* in addition to characters previously mentioned, in having the fore femora and tibiæ practically straight; and in the dorsum of anterior lobe of pronotum being more or less tuberculate at each angle. Venation as shown in Fig. 13. The genotype may be described as follows:

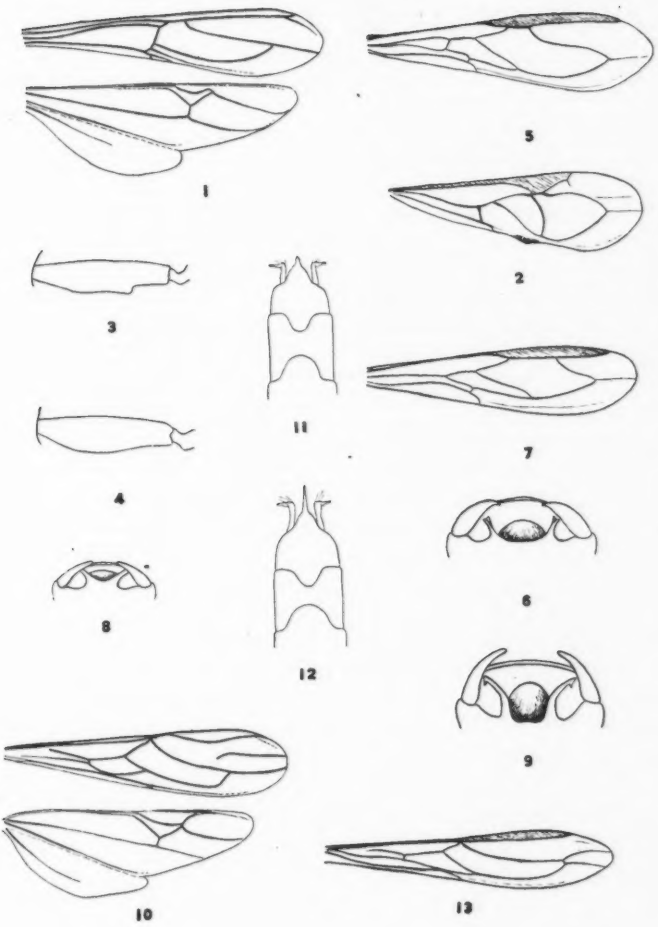
Bagriella ornata new species. General color flavo-testaceous, spines of front legs, a subapical band on each fore femur, a sub-basal one on each fore tibia, two spots on dorsum and the apex also of each fore tibia, base of second segment of beak, eyes, 3 faint bands on mid femur, and 3 on apical half of mid tibia (hind legs missing) 2 oblong spots in posterior discal cell of fore-wing, another in apical cell and fainter maculations elsewhere, fuscous.

Legs, antennæ and base of forewings with long, outstanding whitish hairs. Length, 8 mm.

Holotype ♀, Paraiso, Canal Zone, January 17, 1911, E. A. Schwarz, (U. S. N. M.).

EXPLANATION OF PLATE XVI.

Fig. 1. Bactrodes biannulatus, fore and hind wings.
Fig. 2. Oncerotrachelus acuminatus, fore wing.
Fig. 3. Oncerotrachelus coxatus, fore coxa from side.
Fig. 4. Oncerotrachelus pallidus fore coxa from side.
Fig. 5. Saica apicalis, fore wing.
Fig. 6. Saica apicalis, upper margin of male hypopygium.
Fig. 7. Saica fuscovittata, fore wing.
Fig. 8. Saica tibialis, upper margin of male hypopygium.
Fig. 9. Saica apicalis, upper margin of male hypopygium.
Fig. 10. Tagalis inornata, fore and hind wings.
Fig. 11. Tagalis inornata cubensis, apex of male abdomen from below.
Fig. 12. Tagalis seminigra, apex of male abdomen from below.
Fig. 13. Bagriella ornata, fore wing.



W. L. McAtee and J. R. Malloch.

THE ANATOMY OF THE DIGESTIVE SYSTEM OF THE CAROLINA LOCUST (D. carolina, Linn).*

By HARRISON M. TIETZ.

INTRODUCTION.

The typical insect dissected by most students in biology is the Carolina locust or some other common grasshopper. While many laboratory manuals describe the anatomy of these orthopterons in more or less detail, few if any, are adequately illustrated. Lack of illustration makes it difficult for the instructor to present the subject and leads to confusion in the minds of the students. It is the aim of this paper to meet this need in part by presenting in its text and figures the results of a detailed study of the alimentary tract of the Carolina Locust.

Only one other person, so far as the writer knows, has published on the digestive system of this insect. This article was written by R. E. Snodgrass in 1903 and was issued by the Washington State Agricultural College, Pullman, Washington. His work, however, is not generally accessible and at the same time fails to show structural details.

The present paper forms the third of a series of articles on the anatomy of this insect. In 1917, S. C. Vinal wrote upon the "Respiratory System of the Carolina Locust." This was published in 1919 in the Journal of the New York Entomological Society, Vol. XXVII, 1, p. 19. Later, in 1918, Dr. G. C. Crampton wrote upon the "Thoracic Sclerites of the Grasshopper Dissosteira carolina," which was published in the ANNALS of the Entomological Society of America, Vol. XI, p. 347.

In carrying out this work and in the preparation of the material for publication, the writer has received many valuable suggestion from Drs. H. T. Fernald and G. C. Crampton. To Dr. C. L. Bristol he owes the use of the biological laboratory at New York University during the summer of 1922. It gives him great pleasure to acknowledge here his gratitude for their kindness and encouragement.

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* Contribution from the Entomological Laboratory of the Mass. Agr. College.

METHOD OF STUDY AND PREPARATION OF MATERIAL.

In studying the gross anatomy the procedure was as follows: Specimens were captured in the field and killed in a Cyanide jar. As soon as they were dead they were dissected under water. No alcoholic specimens were used. A Spencer binocular with 10x eyepieces and 55, 40, and 25 mm., objectives were used in making observations.

Material for histological study was dissected from material not quite dead. The alimentary tract in some cases was dropped into Bouins fixitive without being opened. In others the tract was slit and the contents were brushed out under water. After fixation the usual process was followed and the slides were stained with Delafields Hæmatoxylin and Eosin. The finished slides were examined under a B. & L. compound microscope using a 10x eyepiece 32, 8, and 4 mm. objectives. A 1.8 mm. objective was also used. The best sections were those cut 7 to 10 microns thick.

GENERAL CONSIDERATIONS.

On the basis of embryology, the alimentary tract of the Carolina locust can be divided into three regions. The first of these, the fore-gut, is formed by an invagination in the anterior region of the germ band known as the stomodæum. Later this infolded portion is differentiated into mouth, pharynx, œsophagus, crop, gizzard, and cardiac valve. All these, being ectodermal in origin, are characterized by the deposition of chitin which lines their lumen. Following the fore gut is the mid-gut formed from endoderm, and producing the stomach (ventriculus) and its gastric cæca. The remainder of the alimentary tract, generally known as the hind-gut, is ectodermal in origin. This portion of the tract, formed by an invagination of the posterior part of the germ band, is known as the proctodæum, which later forms the pyloric valve, ilium, colon, rectum and anus. The lumen of these portions is also chitinized.

It would be misleading to state that the various portions of the alimentary tract always occupy the same location in the body with reference to the segments. This is true for several reasons: (1) the elasticity of the wall of the gut, (2) the loose attachment of the alimentary tract in the body, and (3) the

distentions of the various portions of the tract as they are filled with food. All these factors will determine the extent of the various portions of the gut with reference to the body segments. The writer, while making dissections of well fed and starved specimens, noted that in the former individuals that portion of the alimentary tract to which the gastric cæca were attached lay in the anterior part of the second abdominal segment, due probably to the distention of the crop and gizzard with food material. In the starved specimens, on the other hand, this area of the digestive system lay in the last thoracic segment.

THE MOUTH AND BUCCAL CAVITY.

The buccal cavity forms the most anterior region of the alimentary tract and its posterior wall is, in part, formed by the tongue or hypo-pharynx. This organ is between 3 and 4 mm. long, rather strongly chitinized, and bears upon its surface fine spines which point backward. These spines, which seem to have a gustatory function, arise from small pits. The writer intends, at some future time, to make a histological study of this organ. On the under surface of the tongue near its tip will be found the opening of the common salivary duct. This duct runs for a very short distance back towards the posterior attachment of the tongue but, before reaching this region, it divides, one branch passing to the right, and the other to the left of the insect. These branches pass into the thorax where they give off smaller branches which connect with the white grape-like clusters of salivary glands. The number and arrangement of these clusters is shown in Fig. 2. These glands are compound alveolar, each alveolus consisting of a mass of glandular cells, irregular in shape, with distinct nuclei. Some seem to be serous cells in which the secretion is scattered throughout the cytoplasm in fine granules. Others appear as mucous cells the secretion being concentrated into a clear glistening drop. In none of the sections could the writer find any indication of a reservoir for their products.

After the food in the buccal cavity has been thoroughly mixed with the saliva, it then passes into the œspohagus.

THE ŒSOPHAGUS.

This is a very short, slender tube extending first upward and backward from the buccal cavity; then, at about where it enters the thorax, bending ventrally somewhat and about the middle of the first thoracic segment joins the crop. The inner surface of the œsophagus is thrown up in longitudinal folds .16 mm. high and is covered with a chitinous coat .024 mm. thick. Under this we find a layer of columnar epithelial cells. These cells have very large prominent nuclei but very indistinct cell walls. Below the epithelium there is a layer of connective tissue which is very prominent in the central portion of the elevations where it forms the "core." Under the furrows between the ridges, however, it is very scant and seems in some places to be wanting. Next in order come the bands of longitudinal muscle. In a few cases we find a band directly under a fold but such strips are generally confined to portions lying between these elevations. The outermost layer consists of circular muscle to the depth of about .03 mm. thick. This is distinctly striated.

The so-called "molasses" glands are supposed by some writers to lie in the œsophagus. In my sections I could see no traces of glandular tissue nor distinct ducts through the chitinous lining. Under the oil immersion the chitin showed some striations but whether these were pores or merely the lamellate structure of the chitin itself the writer could not say. The chitinous intima throughout the whole alimentary tract presented the same appearance.

THE CROP.

The crop can sometimes be distinguished outwardly from the preceding region by its dilated appearance. If the insect has been well fed before dissection, the crop often stands out distinctly from the œsophagus as a sudden dilation of the alimentary tube, but in poorly fed or starved specimens one portion merges into the other so gradually that the limits of each are not clearly seen. Internally, however, the crop is transversely ridged so that it is not difficult to identify it. These ridges, about thirty in number, are about .28 mm. high and spaced .08 mm. apart. The most anterior and posterior ridges are merely a series of short disconnected folds, and the former do not bear the short chitinous teeth mentioned later on.

These teeth are .02 mm. long and are distributed, with the exception just mentioned, along the tops of the ridges in rather even rows, the broader elevations bearing three or four rows, the narrower but a single row. The teeth serve to cut the food into shreds and this seems to be one of the functions of the crop. The ridges may act in such a manner as to retard the quick passage of food into the next region (the gizzard) and so the crop may also serve as a reservoir. A third function of the crop, according to some investigators, is that of straining out foreign material from the food. This function is supposedly carried on by the teeth but Duport shows that the long teeth found in the crop of Gryllus pennsylvanicus do not prevent the passage of large particles into the stomach. In his article (Psyche Dec., 1918) he states, "Particles of chitin, quartz, and woody tissue found in the proventriculus and mesenteron were fully as large as any found in the crop. The action of the proventriculus might be compared with that of the rollers in a mill, anything caught between them is carried onward. If it is strong enough to resist the breaking power of the rollers it will come out unaltered on the other side, if not it will be crushed." Since the teeth of D. carolina are much smaller and do not project as far into the lumen as those of G. pennsylvanicus, they would be less likely to act as strainers. On the other hand, the rigidity they possess owing to their shortness, combined with the fact that they are extremely sharp, favors the theory that the teeth have a triturating function.

The histological elements in the crop are the same as in the œsophagus. The same layers are present and are in the same order. However, the ridges in the crop are transverse instead of longitudinal so we find that their relation to the bands of longitudinal muscle is different. In the œsophagus the bands run parallel to the ridges and between them. In the crop they run at right angles to the ridges. Besides this difference we also find some indication of a thicker layer of circular muscles but this is not marked.

THE GIZZARD.

The external demarcation of the gizzard is not evident for there is but a slight constriction between this portion of the gut and the crop. Posteriorly the outer wall merges into that of the cardiac valve and cannot, therefore, be differentiated from

it. Internally the gizzard can be distinguished by the presence of a series of discontinuous folds or ridge-like elevations grouped in longitudinal rows. These rows, about fifty in number, are from .004 to .008 mm. apart and project into the lumen .09 to .1 mm. Many of the elevations bear one or two teeth, .008 mm. long.

The histology of the gizzard differs somewhat from that of the œsophagus in the following details. The central portion of each protuberance contains very little connective tissue, the epithelial cells being rather tightly packed together. In the basal portion of each elevation, connective tissue is largely replaced by longitudinal muscle. Another very noticeable difference is the great development of circular muscle which is thicker here than at any other part of the tract.

THE CARDIAC VALVE.

The location of this portion of the tract is indicated externally by a slight constriction just anterior to the point of attachment of the gastric cæca. If a longitudinal section be made through the cardiac valve, it will be seen that this portion of the digestive system is very narrow and projects into the ventriculus, the latter having a larger diameter to allow for this intrusion. The small lumen of the valve is further reduced by six elevations which appear as "V" shaped islands projecting from the wall of the valve, the broad part of the V directed anteriorly, the point posteriorly, *i. e.*, near the stomach. These elevations are .5 mm. wide at their widest ends. They are 1.4 mm. long and the notches which give them the V-shaped appearance run about half their length. These protuberances are 1.3 mm. high and bear upon their surfaces fine teeth which become smaller near the apex of the V.

The cellular structure of the cardiac valve is best shown in Figs. 23 and 24. The V-shaped projections are covered with a chitinous coat .02 mm. thick under which lie the epithelial cells. Below these there is a small amount of connective tissue, and under this we find a thick band of circular muscle.

The bands of longitudinal muscle forming an outer coat of the stomach, continue anteriorly until they reach the point of attachment of the gastric cæca. Here some divide and go around on either side of the cæca, uniting on the other side where they form an incomplete outer coat of the cardiac valve. This coat

runs for a very short distance ending just below the point where the V-like projections begin. The remaining longitudinal fibres may form the outer coat of the cæca.

This portion of the alimentary tract may prevent the food from passing too rapidly from the gizzard to the stomach as well as preventing regurgitation of the food already in the stomach.

THE STOMACH (ventriculus).

There are two characters that enable one to identify the stomach without cutting into the alimentary tract. These characters are as follows: (1) the nature of the stomach wall, and (2) the presence of the gastric cæca. The wall is very thin, being not more than .02 mm. thick. This character gives it a white translucent appearance which is very noticeable. The gastric cæca which serve as a second means of identification mark, at their point of attachment, the anterior limit of the stomach. These organs, sometimes called diverticula or appendices ventricularis, are six in number and are paired, each cæcum having a single point of attachment to the wall of the stomach from which point there is directed anteriorly a finger-like lobe, and posteriorly a pouch. This finger-like lobe is nearly twice as long as the pouch and the latter is sometimes reduced making it still shorter. Both lobes and pouches are blind pockets being closed at their distal ends and open at their proximal ends into the stomach. The openings of the six pairs of cæca are not confluent but are so arranged that a line drawn through their openings would encircle the tract. The longitudinal axes of the cæca run parallel to the longitudinal axis of the alimentary tract.

In D. carolina both the anterior and posterior pouches of each cæcum are covered by a layer of smooth longitudinal muscle. The other cellular layers, however, differ both in structure and arrangement. In the anterior lobe, beneath the muscular coat just mentioned, there is a very thin layer of connective tissue though in many places this is not evident. Inside this lies the epithelium which is thrown up into twelve or thirteen longitudinal folds (Figs. 18 and 19). These folds project so far into the lumen that they almost divide each pouch into compartments. The epithelial cells are columnar with distinct nuclei situated near their bases, the cytoplasm is densely gran-

ular, and the free surfaces of each cell appears ciliated. In the posterior lobe there seems to be no definite arrangement of the cells. Many are irregular in shape, all are closely packed, and they fill the lobe with the exception of a small lumen in the center. The nuclei are very distinct, the cytoplasm not densely granulated, and none of the cells are ciliated. Although the gastric cæca are outgrowths of the stomach, this latter organ shows histological characters peculiar to itself. Instead of one layer of muscles we find two. The outermost is unstriated and longitudinal. Next to this comes a layer of circular muscle which also appears unstriated. Permeating the rest of the wall of the stomach are a few strands of connective tissue in which lie imbedded two types of cells. In the first type both the nuclei and cytoplasm stain deeply. The cells are very closely packed together with their cell walls not perceptible. They appear as dome shaped masses in longitudinal sections and as columns when viewed in cross section. Between these masses there are crypts or nests of nuclei (nidi) which form the second type of cell. Their nuclei stain well but not so deeply as in the first type. The surrounding cytoplasm remains very clear and unstained. Many of the cells appear polynucleated probably owing to the fact that their cell walls are imperceptible. They have all the appearances of being centers for the generation of new cells needed to replace those destroyed during the process of digestion.

It has been claimed that there is a chitinous intima lining the inner surface of the stomach but the writer could find no evidence of its presence. Instead that portion of the stomach wall next to the lumen was composed of disintegrating cells with here and there scattered nuclei. From the sections studied, the writer is under the impression that the nidi are centers where new cells are constantly being produced and that these cells then migrate towards the lumen where they are broken down during the process of digestion.

THE MALPIGHIAN TUBULES.

It has been mentioned that the attachment of the gastric cæca outwardly mark the anterior boundary of the stomach. For convenience the Malpighian tubules may be considered as marking the posterior limit of the stomach at the point where they are attached to the alimentary tract. It should be remem-

bered, however, that these tubules are proctodæal in origin and are not, therefore, part of the stomach. In fact the tubes enter the tract just in front of the pyloric valve.

The Malpighian tubules are threadlike in appearance, about seventy in number, and are pigmented most of their length, though near their points of attachment no color is present. In the specimens examined the color was a very dark brown and so distributed as to give the tubules the appearance of being either transversely ringed or banded and blotched. The tubes are about .05 mm. in diameter and vary in length, the longer ones measuring ten millimeters or more. They are composed of cells with prominent nuclei but with indistinct cell walls. The cells rest upon a very thin basement membrane and the latter is in close contact with trachioles that wind themselves about the tubules even to their tips. There seems to be no lumen near their points of attachment. At their point of attachment to the gut wall, the Malpighian tubules are grouped in six masses of about twelve tubes each. While the tubes do not coalesce but retain their individuality from their place of insertion to their most distal point, each group has but a single common opening.

THE PYLORIC VALVE.

The ilial muscles might force the contents of the ilium back into the stomach were it not for the presence of the pyloric valve. This valve consists of (1) a transverse fold shown in Fig. 8, and (2) somewhat spherical elevations situated just posterior to the fold. When viewed from the inner surface, this fold appears as a ditch cut transversely in the wall of the digestive tube. At the bottom of this ditch we find six cup-shaped depressions. When viewed from the outer surface, these depressions become six dome-like elevations .12 mm. high and it is to these protuberances that the Malpighian tubules are attached. These tubes as Miall states have only a secondary connection with the alimentary canal depending as it would seem upon intercellular communication and not to clearly defined ducts for the passage of waste products into the digestive tract.

The spherical elevations posterior to the fold are of the same structure as that of the ilium to be discussed later on. Anteriorly each elevation is .24 mm. in diameter but posteriorly

it is drawn out gradually, becomes narrower and at the same time slopes down towards the wall of the ilium. Finally its identity is lost for it merges into the many folds of the ilial epithelium. The longitudinal axes of these elevations run parallel with the longitudinal axis of the alimentary tract. They do not normally touch each other being spaced about .4 mm. apart. It seems reasonable to suppose, however, that when the circular muscles of the ilial wall contract, thereby reducing the diameter of the lumen, these projections may be brought together, may touch each other and thereby close up the anterior end of the ilium. Such a stoppage would prevent the contents of the ilium from re-entering the stomach.

THE ILIUM.

This is a rather short, straight, tapering tube whose posterior diameter is about one-half that of the anterior end. Externally, the limits of the ilium are only roughly indicated. One can consider that portion of the alimentary tract to which the Malpighian are attached as the anterior limit of the ilium. Posteriorly this portion of the digestive system extends to the first constriction behind these tubes.

Internally, the wall of the ilium is thrown up into many longitudinal folds that rise about .32 mm. from its surface. They are connected by similar folds which take a more or less oblique direction. These two types of elevations give to the inner ilial wall a much wrinkled appearance. Since one of the functions of the ilium is absorption, these numerous folds serve to increase the absorptive surface.

The epithelium forming the folds consists of a single layer of cuboidal cells whose free surface is covered with chitin to a depth of .008 mm. The central portion of each fold is loosely filled with connective tissue upon which these cuboidal cells rest. Next comes a thin coat of circular muscle outside of which and forming the outermost portion of the ilium, there are about six bands of longitudinal muscle.

THE COLON.

It is often difficult to recognize the colon without cutting through its wall and examining the internal structure. When the six longitudinal bands of muscles, to be mentioned later on,

appear through the wall and when the constrictions between the ilium and colon, and colon and rectum are pronounced, external identification is made much easier.

Internally, however, this portion of the alimentary tract presents unmistakable characters that would prevent its confusion with any other region of the digestive system. The outstanding features are the six longitudinal folds, .24 mm. high, that project into the lumen of the colon.

They are about .2 mm. broad and are placed about .012 mm. apart. The tops of these elevations are not flat but, on the contrary, present under the microscope a rather undulating appearance. These elevations are continuations of the ilial folds.

The histology of the colon is quite similar to that of the ilium with the exception that the chitinous intima in the colon is thicker being .012 mm. in depth. There is also a noticeable increase in the amount of circular muscle. The longitudinal muscles of the colon are merely continuations of the ilial muscles.

THE RECTUM.

The rectum begins just behind the last constriction of the alimentary tract, this constriction marking it off from the colon. From this point it dilates then gradually tapers to the anal opening. In addition to this character, the six bands of longitudinal muscles that appear as dark streaks on the outer rectal wall, also aid in fixing the limit of the rectum although the muscular bands may sometimes be seen on the colon wall as well.

Upon dissection it will be noticed that the six folds in the colon have been continued into the rectum, where they have undergone some modifications. In the rectum the folds have been reduced in height to .12 mm., but their width has been increased to .58 mm. at their widest part though they become narrower as the rectum tapers. With an increase in the width of the folds, there is a proportional decrease in their distance apart, each elevation rising within .008 mm. of its neighbor causing the intervening furrows to be very narrow. Lastly, the surface of the rectal folds are fairly smooth and flat.

The musculature of the rectum consists of a thin layer of circular muscle outside of which lie six rows of longitudinal muscles. These longitudinal muscles are placed just opposite the

furrows between the rectal folds and are, therefore, external indications of the location of these elevations.

The epithelium of the rectum consists of columnar cells closely packed together whose nuclei and cell walls are well marked. The chitin lining the lumen appears, in all my sections, to be very thin.

At the posterior end of the rectum, all the characters that have just been mentioned are lost or become very indistinct. Finally the rectum opens to the exterior through the anus. The anus marks the posterior limit of the intestine and is situated above the genital opening.

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EXPLANATION OF PLATES XVII—XXI.

Fig. 1. Sagittal section of the alimentary tract in situ.
Fig. 2. General external view of the alimentary tract from dorsal surface.
Fig. 3. Longitudinal profile of the alimentary tract (vertical and horizontal scales different. Letters refer to the location of the sections figured.)
Fig. 4. Diagrammatic reconstruction of the oesophagus.
Fig. 5. Diagrammatic reconstruction of the crop.
Fig. 6. Diagrammatic reconstruction of the gizzard.
Fig. 7. Diagrammatic reconstruction of the cardiac valve.
Fig. 8. Diagrammatic reconstruction of the pyloric valve.
Fig. 9. Diagrammatic reconstruction of the colon.
Fig. 10. Diagrammatic reconstruction of the rectum.
Fig. 11. Section through an alveolus of a salivary gland.
Fig. 12. Cross section of the oesophagus.
Fig. 13. Long. section of the oesophagus.
Fig. 14. Cross section of the crop.
Fig. 15. Long. section of the crop.
Fig. 16. Cross section of the gizzard.
Fig. 17. Long. section of the gizzard.
Figs. 18 and 19. Cross sections of the cardiac valve.
Fig. 20. Cross section of the cardiac valve at the point where the posterior lobes of the gastric cæcæ open into the stomach.
Fig. 21. Cross section of a Malpighian tubule with trachea.
Fig. 22. Long. section of a Malpighian tubule.
Fig. 23A. Long. section of the cardiac valve.
Fig. 23B. Epithelial cells from the anterior lobe of the gastric cæcæ showing cilia?)
Fig. 24. Long. section of the cardiac valve between gastric cæcæ.
Fig. 25. Cross section of the stomach.
Fig. 26. Oblique cross section of the stomach.
Fig. 27. Long. section of the stomach.
Fig. 28. Oblique long section of the stomach.
Fig. 29. Cross section pyloric valve.
Fig. 30. Long. section pyloric valve.
Fig. 31. Cross section of the ilium.
Fig. 32. Long. section of the ilium.
Fig. 33. Cross section of colon.
Fig. 34. Long. section of colon.
Fig. 35. Cross section of rectum.
Fig. 36. Long. section of rectum.

KEY TO ABBREVIATIONS.

A.—Hypopharynx.
B.—Salivary Duct.
C.—Oesophagus.
D.—Crop.
E.—Salivary Gland.
F.—Gizzard.
G.—Anterior lobe of Gastric Cæca.
H—Posterior lobe of Gastric Cæca.
I.—Malpighian Tubule.
J.—Trachea.
K.—Stomach.
L.—Ilium.
M.—Colon.
N.—Rectum.
O.—Anus.

ci.—Cilia.
c. d.—Cup-shaped Depressions.
chi.—Chitin.
c. m.—Circular Muscle.
c. t.—Connective Tissue.
c. v.—Cardiac Valve.
d.—Duct.
d. c.—Disintegrating Cells.
epi.—Epithelium.
l. m.—Longitudinal Muscle.
m.—Membrane.
m. c.—Mucous Cells.
n.—Nidi.
p. v.—Pyloric Valve.
r. g.—Rectal Gland.
s. c.—Serous Cells.
t.—Teeth.
tr.—Trachea.
v.—V-shaped Islands.

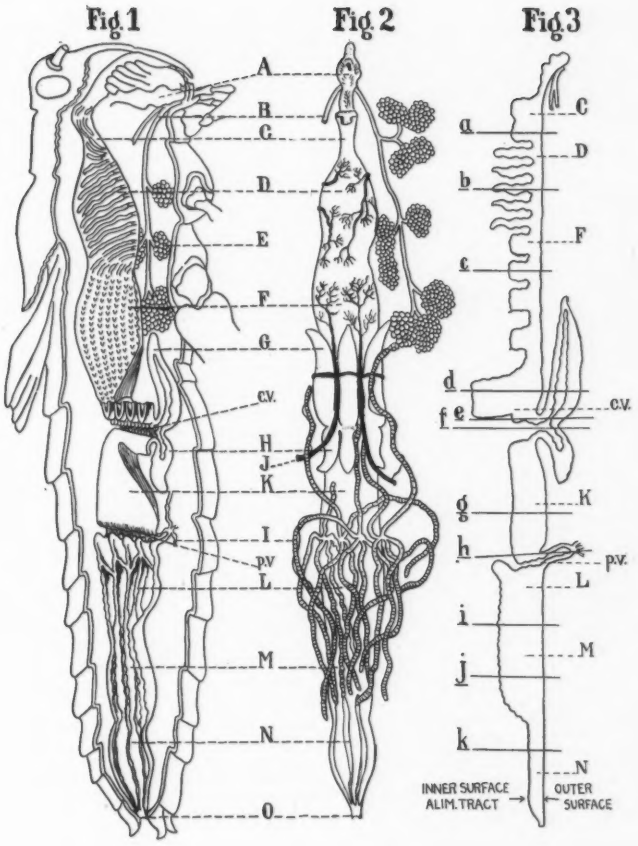

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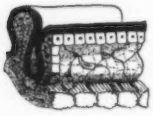
Fig.4



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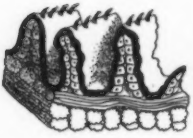

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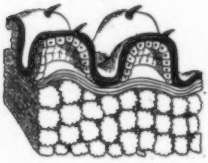

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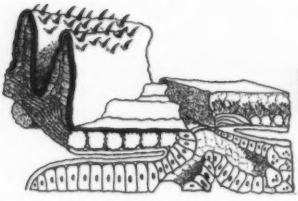

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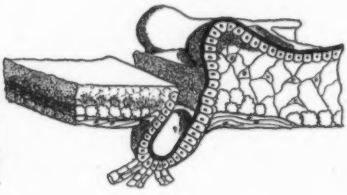

Fig.9

Fig.10

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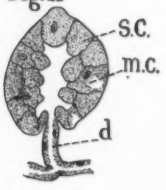

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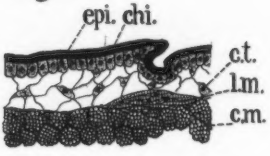

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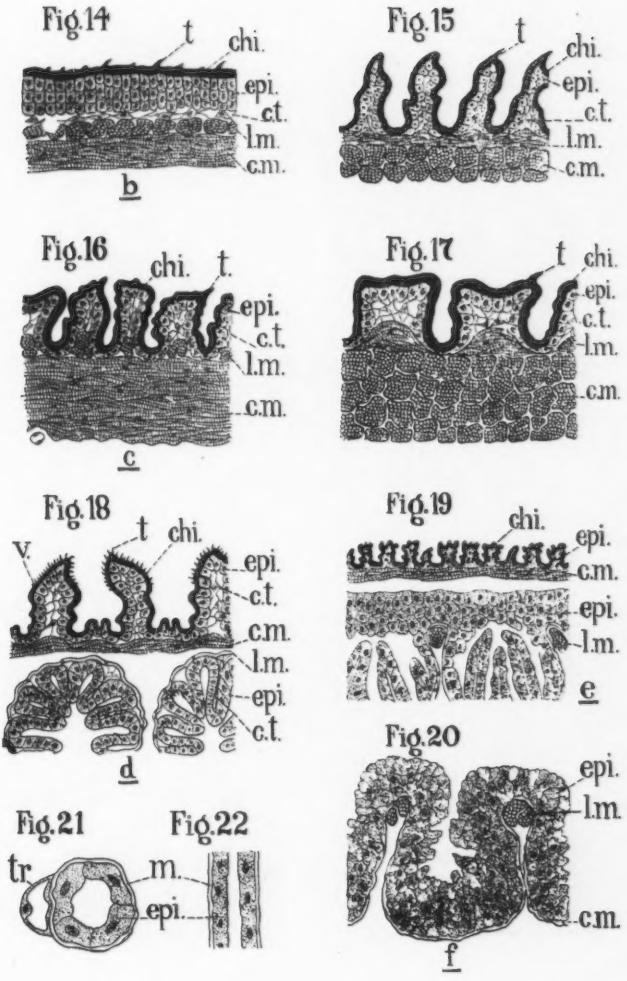

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Fig.23A

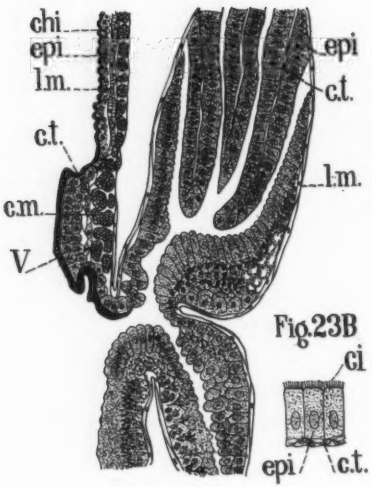
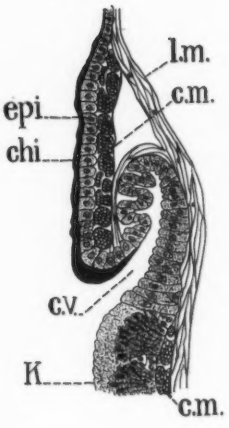


Fig.23B

Fig.24



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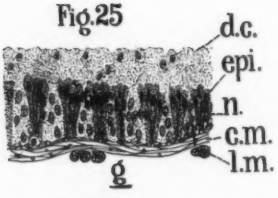

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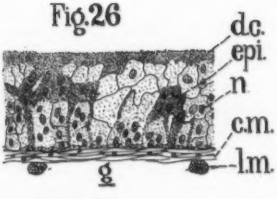

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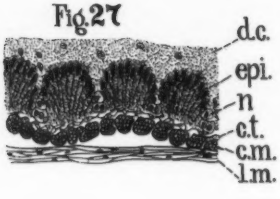

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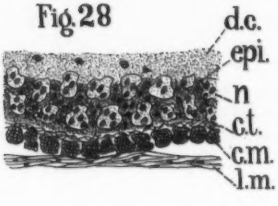

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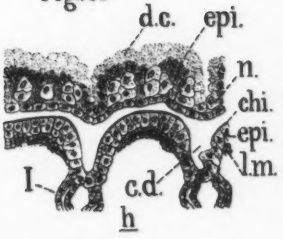
Fig.29



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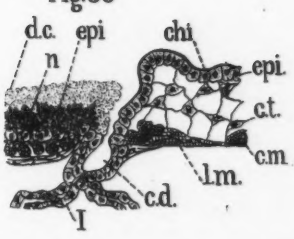

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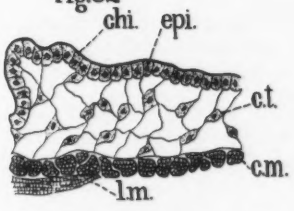

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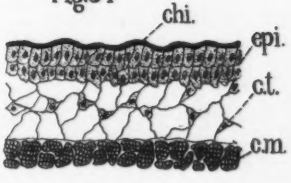

Fig.35

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NOTES ON COLLECTING INSECTS IN THE MARQUESAS ISLANDS.

F. L. WASHBURN.

On September 8, 1922, I sailed from San Francisco equipped for a collecting trip in the Marquesas and Society Islands, having been granted a six months sabbatical leave by the University of Minnesota for that purpose. Before my return and because of the uncertainty of travel to and from the Marquesas, this leave was extended to cover eight months.

Returning recently, it has occurred to me that members of the American Society and other Entomologists would be interested in the results.

We did not expect to find in the Marquesas any brilliant forms, and in this were not disappointed, but we were agreeably surprised in meeting with far more insects, both species and individuals, than we expected.

It is too early to speak definitely of the species taken, but the following data may be acceptable to collectors and particularly to any entomologist planning a trip to this far-away country.

Our equipment consisted, in addition to many and various nets and extra scrim, and cyanide jars—of 6-inch glass vials filled with a 4% solution of formaldehyde, many round tin salve boxes, as well as large square and oblong tin boxes, adhesive tape and (to protect the latter when used to seal the boxes, from the effect of moisture) a supply of waxed paper. We also took cellu-cotton, and most important, an iron kerosene lamp with two broadwicks and a small iron drying oven. Equally important were two iron-lined wooden boxes about 14 x 14 x 16 inches with rabbetted covers, which drew down very tightly by means of trunk cover clasps. A supply of napthalene crystals was included in our outfit, and more useful still, almost indispensable, crystals of tetra-di-chloride of benzine. This latter we found excellent in ridding our trunks of cockroaches before returning to civilization, though its chief use is given below. We also took a lantern trap (which proved nearly useless) extra cyanide and ether and chloroform. Trowels, knives, forceps, etc., were in evidence, and we added a small bore shotgun and ammunition, cotton, arsenic and alum, for collecting birds and making skins; a rifle to secure fresh meat (wild goats, pigs and cattle) also formed a part of our outfit. We provided ourselves with two good cameras, many "tropic" films in machine-sealed metal containers, two field developing outfits and plenty of chemicals for developing. A thermometer to use in testing temperature of water in developing is highly important. An extra tripod or two should have been packed with our luggage. An army cot, mattress and mosquito canopy, double blanket and pillow we found necessary, and a good field glass

proved very useful. Ammonia for alleviating poison effects of centipedes and a medicine kit for emergencies were wisely added. These things filled two large packing cases, and when I saw natives struggling in the surf to get our luggage on the beach at Tuahuku on Hivaoa without wetting it, I resolved that on a second trip I would put everything possible into strong sacks, and avoid large boxes.

Immediately after insects were killed, i. e., after I had returned to camp, some were placed in formaldehyde in vials and localities marked on the corks. Of course most of our specimens were dried. Those intended for drying were laid on cellu-cotton in the above mentioned tin boxes and placed in oven over lamp. Drying took from four to seven or eight hours. When in our estimation they were dry, a layer of cellu-cotton was placed over them, a few crystals of paradichloride of benzine scattered on this, the cover replaced and a band of adhesive tape run around the box. The data were scratched on box. It followed only to wrap each box in waxed paper, fasten same on with rubber band and pack boxes in our small iron-lined chests where they were safe from attack by insects, rats, mice or mould. Some of these boxes have been opened since reaching home and specimens have been found to be in excellent condition.

Most of the insect specimens were collected from 50 to 100 feet above the sea, but many were taken between a 1,000 and 2,000 feet elevation and some at 2,800 feet. In almost every order we have sufficient specimens to allow of exchange with other institutions.

Hymenoptera led in point of numbers and in this order a large imported Vespid was extremely abundant and at times troublesome. Everywhere imported honey bees (and for the most part a good strain of Italians) were kept by natives, in such primitive hives and in so unskilled a manner that we knew, even before we were told, that there were many escaped swarms and much wild honey. We took four species of *Formicidæ*, one species, perhaps two of *Ichneumonidæ*, and reared a few parasites from scale insects.

Of *Lepidoptera* we obtained three species of diurnals, including one apparently identical with our *Anosia plexippus* and this was found in varying abundance on the four islands visited, namely, Hivaoa, Tahuata, Uapu and Nukahiva. Two handsome Sphingids, some Noctuids, and other small nocturnal forms were taken. I did not observe the Monarch on either Tahiti or Morea, but it doubtless occurs and has been so recorded.

Diptera.—The Marquesas yielded a black Syrphid with yellow bands and a most interesting robust form with metallic reflections, which I found very abundant. Two or three species of mosquitoes were taken and we were especially interested in discovering that the famous "No-No" or "sandfly" occurring in great numbers on Nukahiva were Simuliids, genus and species to be determined later.

Many fruit flies were taken on rotting mangoes and guavas.

Houseflies were common everywhere, but not very abundant or troublesome.

A few specimens of Aptera were secured on Nukahiva. The presence of many dogs on all these islands insures the finding of fleas anywhere, though strangely enough we examined a dozen or more house rats, very common everywhere, immediately after death, and found none.

In *Homoptera* we took many Coccids, several species of Aleurodids, a few species of plant lice. In *Heteroptera*, a few bugs.

It is interesting to note that in three months of work in the Marquesas I found no insect which passes its adult stage in or on water. On Tahiti, in the Society group, I took one Hydrobatid.

In *Odonata*, which were quite numerous as to individuals, perhaps six species were taken.

Orthoptera yielded Gryllids, two or three species of "walking sticks," several locustids, one very large green Acridid, taken only in one valley on Nukahiva, and of course we found Blattids in abundance.

In *Coleoptera* several species of Cerambycids were captured, as were one or two forms of Coccinellids, a handsome green and bronze Buprestid occurring to the best of my knowledge only in Uapu and Fatuhiva; several species of Ryncophora; some Staphylinids were taken in rotting fruit.

Neuroptera: A lace-winged fly, closely resembling Chrysopa, was present, on all the islands visited, in thousands. On Tahiti (Society group) an interesting Ant Lion, looking like our Myrmelon, was secured.

Euplexoptera: Represented in our collection by one species.

Isoptera: A few white ants secured. These, by the way, are becoming very abundant and troublesome in Tahiti.

The trip from Tahiti to the Marquesas, 790 miles away, can only be taken in small trading schooners, occupies from 6 to 9 days, or frequently 15 or 20, or more depending upon whether or not the boat goes through the Paumotus, and the journey is a hardship.

But little in the way of equipment can be purchased in these islands; it has to be carried in and one is wise to take everything in duplicate as far as possible. An emergency kit of medicine is an important part of the outfit and we would strongly advise one taking about three times as much iodine as he deems necessary, for wounds heal slowly and the chance for infection is great. Clinical thermometers should not be forgotten. It is of the utmost importance to take a saddle and bridle from America. In the Marquesas one is dependent upon their small horses (Peruvian stock) for transportation and the above commodities are hard to obtain, costing more than the horse.

A pup tent may be found very useful. One should also take two or three pairs of strong army shoes or cruising boots. The volcanic rock is hard on shoe leather. Light shoes or slippers are also advisable for use after day's work. Thin clothes and cork helmets can be bought cheaply at Papeete, Tahiti. Helmets are necessary; no white man can work in the sun in a straw hat; at least we could not. A good flash light (or better, two flash lights) will be found very serviceable and necessary.

Since money is not always desired by the natives, articles for trading (to secure labor and other service) are useful. The following will be found acceptable: Pipes, tobacco, caps, shirts, playing cards, watches, (the latter only given for great favors) mouth organs, whistles, flash lights, fish hooks, belts, necklaces, dolls and colored calico. Letters of introduction from prominent officials in this country are most acceptable to the French government. We found them very useful.

Finally, one should avoid using large boxes for his equipment. Strong sacks are preferable, as landings in the Marquesas are for the most part very difficult.

TECHNIQUE IN STUDYING BY DISSECTION THE INTERNAL ANATOMY OF SMALL INSECTS.

RALPH H. SMITH,
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While engaged a few years ago in studying the morphology of the digestive apparatus of some small Hemiptera, including Coccidæ, Aphididæ, Tingidæ, Cicadellidæ, etc., the writer hit upon a method of dissection, some features of which apparently have not heretofore come to the attention of students of morphology. Brief description of the technique is given herewith.

Delicate dissecting knives and needles are made by grinding down needles ranging from the fine cambric needle to darning needles. Surgeons' needles are very suitable. These are inserted in sections of slender stems or sprouts of woody plants, which serve as handles. Finishing of the edges and points, as also the delicate points on forceps, is done on a fine carborundum under a binocular microscope. A Syracuse Dish or Stender Dish is partially filled with paraffine of a fairly high melting point. The insect, with the wings and legs removed from one side, is held with the fine-pointed forceps. Using a blunt, heated needle, a small place is melted in the paraffine and the lower one-half or two-thirds of the insect's body—the side having the appendages intact—is submerged in the melted paraffine. By using a needle, frequently heated, the paraffine is brought in close contact with the integument. The dissecting dish is then filled with normal salt solution.

The dissection is performed as follows: Insert point of the dissecting knife through the integument and cut outward along edge of the firm paraffine. Then with fine forceps and dissecting needle, carefully lift away the upper half of the exoskeleton. The internal organs are thus exposed in their natural positions. The tissues of minute insects are so delicate and so nearly transparent that a staining reagent must be used to differentiate the various organs. For this purpose, a weak aqueous

solution of iodine is found much superior to the stains ordinarily employed in such dissection work. A medicine dropper with the end drawn to a suitably fine point over a gas or alcohol flame, is used to best advantage in applying the iodine solution.

To bring out the salivary glands, for example, a delicate stream of the iodine is forced against the tissues of the head. The different tissues respond immediately, though in slightly different degrees. All tissues are contracted, but as the iodine diffuses in the water, they relax to approximately their natural size, shape and color. Care must be given to cleaning the dissection instruments after using, as the iodine and salt corrode them quickly.

When the higher power objectives and oculars of the binocular microscope are used, as usually is necessary, very strong light is required. In this case the dissecting stand is placed in direct sunlight, or the rays from a high power electric lamp are condensed through a bull's eye lens, or a microscope lamp may be used to illuminate the object; each method having given satisfactory results. The use of paraffine for holding larger insects and larvæ in position while dissecting, is often much more satisfactory and expeditious than the method of pinning as employed by many students of insect morphology. Likewise, the iodine solution works equally well with the larger insects.

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1914. SCHWARZ, EUGENE AMANDUS, U. S. National Museum, Washington, D. C. (Ch. 1907).

FELLOWS.

1907. ALDRICH, J. M., National Museum, Washington, D. C. (Ch.) Diptera.
1920. ALEXANDER, C. P., Fernald Hall, Massachusetts Agr. College, Amherst, Mass. (1910). Tipulidæ.
1908. BALL, E. D., U. S. Dept. Agr., Washington, D. C. (Ch.) Jassidæ, Cercopidæ, Membracidæ, Fulgoridæ.
1914. BANKS, NATHAN, Museum Comp. Zoology, Cambridge, Mass. (1908).
1913. BARNES, WM., 320 Millikin Bldg., Decatur, Illinois. (Ch.).
1908. BEUTENMULLER, WM., Box 258, Highwood, New Jersey. (Ch.) Cynipidæ.
1920. BEZZI, MARIO, Via Pio Quinto, 3, Torino, Italy. (1918).
1914. BRADLEY, J. CHESTER, Cornell University, Ithaca, N. Y. (Ch.).
1914. BRITTON, W. E., Agr. Exp. Sta., New Haven, Conn. (Ch.). Aleyrodidæ.
1914. BRUES, C. T., Bussey Institution, Boston 30, Mass. (Ch.).
1907. BRUNER, LAWRENCE, Auburn, Calif. (Ch.).
1917. BURGESS, A. F., Melrose Highlands, Mass. (Ch.). Carabidæ.
1917. CAESAR, LAWSON, Ont. Agr. Coll., Guelph, Ontario, Canada. (1912).
1907. CALVERT, P. P., Zool. Lab., Univ. Pennsylvania, Philadelphia. (Ch.). *Odonata.*

1917. CHAMBERLIN, R. V., Museum Comp. Zoology, Cambridge, Mass. (Ch.).
1908. COCKERELL, T. D. A., 908 Tenth St., Boulder, Colo. (1907). Bees, Fossil Insects.
1917. CRAMPTON, GUY C., 86 Pleasant St., Amherst, Mass. (1911).
1917. DAVIS, JOHN J., Agr. Exp. Sta., Lafayette, Ind. (Ch.). Aphididæ, *Lachnosterna.*
1917. DAVIS, WILLIAM T., 146 Stuyvesant Place, New Brighton, Staten Island, N. Y. (Ch.). Cicadas, Orthoptera.
1917. DEAN, GEO. A., Kansas State Agr. Coll., Manhattan, Kansas. (1913).
1907. EMERTON, J. H., 30 Ipswich St., Boston, Mass. (Ch.). Spiders.
1907. FALL, H. C., Tyngsboro, Mass. (Ch.). *Coleoptera.*
1908. FELT, E. P., State Museum, Albany, New York. (Ch.). Itonididæ.
1914. FERNALD, H. T., Mass. Agr. Coll., Amherst, Mass. (Ch.). Sphecidæ.
1907. FOLSOM, J. W., Box 32, Homer, Ill. (Ch.). *Collembola, Thysanura.*
1920. FUNKHOUSER, W. D., Univ. Kentucky, Lexington, Ky. (1911). Membracidæ.
1917. GIBSON, ARTHUR, Dominion Entomologist, Ottawa, Canada. (Ch.).
1907. GILLETTE, C. P., Fort Collins, Colo. (Ch.).
1920. HEADLEE, THOMAS J., New Brunswick, N. J. (Ch.).
1917. HEBARD, MORGAN, Chestnut Hill, Pa. (Ch.). Orthoptera, *Blattidæ.*
1907. HENSHAW, SAMUEL, 28 Fayerweather St., Cambridge, Mass. (Ch.).
1914. HERRICK, GLENN W., 219 Kelvin Place, Ithaca, N. Y. (Ch.). Mallophaga, Diaspinæ.
1914. HINE, JAS. S., Ohio State Univ., Columbus, Ohio. (Ch.). Tabanidæ, Asilidæ.
1907. HOLLAND, W. J., Carnegie Museum, Pittsburgh, Pa. (Ch.).
1907. HOPKINS, A. D., U. S. Dept. Agr., Washington, D. C. (Ch.).
1907. HOWARD, L. O., U. S. Dept. Agr., Washington, D. C. (Ch.). Aphelininæ.
1921. HUNTER, S. J., University of Kansas, Lawrence, Kansas. (Ch.).
1914. JOHANNSEN, O. A., Roberts Hall, Cornell Univ., Ithaca, N. Y. (Ch.). Diptera.
1907. JOHNSON, CHAS. W., Boston Society Nat. Hist., Boston, Mass. (Ch.). Diptera.
1907. KELLOGG, VERNON, Nat. Research Council, 1701 Mass. Ave., Washington, D. C. (Ch.). Mallophaga, Anoplura.
1920. KNAUS, W., McPherson, Kans. (Ch.). *Coleoptera.*
1917. LENG, C. W., 33 Murray St., New York City. (1912).
1917. LUTZ, FRANK E., Amer. Mus. Nat. Hist., New York City. (Ch.).
1920. MCDUNNOUGH, J., Entomological Branch, Ottawa, Canada. (1912).
1908. MACGILLIVRAY, ALEX. D., 603 W. Michigan Ave., Urbana, Ill. (Ch.). Saw-flies, Coccids, Insect Morphology.
1908. MARLATT, C. L., U. S. Dept. Agr., Washington, D. C. (Ch.). Cicadidæ, Coccidæ.
1917. MARSHALL, WM. S., 139 E. Gilman St., Madison, Wis. (Ch.). Anatomy and Embryology.
1914. MELANDER, A. L., State Coll., Pullman, Wash. (Ch.). Diptera.
1920. METCALF, C. L., Nat. Hist. Bldg., Univ. Illinois, Urbana, Ill. (1912). Animal Parasites. *Syrphidæ.*
1914. MORSE, ALBERT P., Peabody Museum, Salem, Mass. (Ch.). Orthoptera.

1920. Mosher, Edna, Univ. New Mexico, Albuquerque, N. M. Immature Insects.
1917. Muir, F., H. S. P. A. Exp. Sta., Honolulu, Hawaii. (Ch.).
1907. Needham, James G., 6 Thurston Ave., Ithaca, N. Y. (Ch.). Odonata, Ephemerida, Plecoptera.
1907. Osborn, Herbert, Ohio State Univ., Columbus, Ohio. (Ch.). Homoptera, *Cicadellidæ*.
1917. Osburn, Raymond C., Botany-Zool. Bldg., Ohio State Univ., Columbus, Ohio. (Ch.). Syrphidæ.
1914. Parrott, P. J., Agric. Exp. Sta., Geneva, N. Y. (Ch.).
1914. Patch, Edith M., Exp. Sta., Orono, Me. (Ch.). Aphiidæ.
1914. Quaintance, A. L., Bur. Entom., Washington, D. C. (Ch.).
1914. Rehn, James A. G., Academy Nat. Sci., Logan Square, Philadelphia, Pa. (Ch.). Orthoptera, Dermaptera.
1914. Riley, W. A., University Farm, St. Paul, Minn. (Ch.). Tabanidæ.
1920. Sanders, J. G., Bur. Plant Ind., Harrisburg, Pa. (Ch.). Cicadellidæ, Coccidæ.
1920. Schaus, William, U. S. Nat. Mus., Washington, D. C. (1919). Lepidoptera.
1920. Shelford, Victor E., Vivarium Bldg., Champaign, Ill. (Ch.). Cicindelidæ, Ecology.
1920. Silvestri, Filippo, R. Scuola Superiore d'Agricoltura, Portici, Italy. (1915). Thysanura, Protura, Termites, Myriopods.
1907. Skinner, Henry, Logan Sq., Philadelphia, Pa. (Ch.). *Rhopalocera*.
1914. Slosson, Annie T., 36 Gramercy Park, New York City. (Ch.).
1921. Swaine, J. M., Dept. Agric., Ottawa, Canada. (1920).
1912. Van Duzee, E. P., Cal. Acad. Sciences, San Francisco, Calif. (Ch.).
1917. Van Dyke, Edwin C., Univ. Calif., Berkeley, Calif. (Ch.). Coleoptera, Elateridæ, Carabidæ.
1914. Walker, E. M., Univ. Toronto, Toronto, Canada. (1910). *Odonata, Orthoptera*. (Canadian species).
1920. Welch, P. S., Univ. Michigan, Ann Arbor, Mich. (1912). Aquatic Lepidoptera.
1907. Wheeler, W. M., Bussey Institution, Boston 30, Mass. (Ch.). Ants.
1914. Wickham, H. F., 911 E. Iowa Ave., Iowa City, Ia. (Ch.). Coleoptera.
1920. Williams, C. B., Ministry of Agric., Cairo, Egypt. Thysanoptera, *Tomaspis*.
1914. Williamson, E. B., Bluffton, Ind. (Ch.). *Odonata*.

MEMBERS.

1908. Ainslie, C. N., 5009 Orleans Ave., Sioux City, Iowa. Hymenoptera, Microhymenoptera.
1907. Ainslie, G. G., R. D. No. 9, Knoxville, Tenn. *Crambinæ, Aphididæ, Jassidæ*, Thysanoptera.
1913. Allee, W. C., Zoology Bldg., Univ. Chicago, Chicago, Ill. Insect Behavior.
1922. Allen, A. R., Jr., B. 22, Give Hall, Cambridge, Mass.
1922. Arnold, George F., State Plant Board, A. & M. College, Miss. Cerambycidæ.

1918. Babcock, O. G., Box 407, Sonora, Texas. Mallophaga and Anopleura.
1922. Baerg, W. J., Fayetteville, Ark.
1919. Baird, A. B., Dom. Ento. Lab., Box 845, Fredericton, N. B., Canada. Parasitic Hymenoptera.
1911. Baker, A. C., East Falls Church, Va. *Aphiidæ* and *Aleyrodidæ*.
1912. Baker, A. W., Ontario Agr. College, Guelph, Canada. *Mallophaga*, Coleoptera.
Ch. Baker, C. F., Los Banos, Philippines. Jassoidea, Fulgoridea.
1922. Baker, Howard, 88 Pleasant St., Amherst, Mass.
1919. Balduf, W. V., University of Illinois, Urbana, Ill. Chrysomelidæ.
1922. Banghart, Joseph, 934 Hollister St., Olney, Ill. *Lepidoptera, Coleoptera.*
Ch. Banks, C. S., Bureau of Science, Manila, Philippines. Diptera, Hemiptera.
Ch. Barber, H. G., 143 Third Avenue E., Roselle, N. J. *Hemiptera-Heteroptera.*
Ch. Barber, H. S., U. S. National Museum, Washington, D. C.
1913. Barber, L. S., Florida State College for Women, Tallahasse, Fla.
Ch. Barlow, John, State College, Kingston, R. I.
1922. Bartley, Hastings N., 40 Hanover Road, Silver Creek, N. Y.
1918. Basinger, A. J., State Insectary, Capital Park, Sacramento, Calif.
1922. Batchelder, Charles H., 38 N. Main St., Orono, Maine.
1914. Baumberger, J. P., 2520 Folsom St., San Francisco, Calif.
1922. Beal, James A., 496 Linwood St., Abington, Mass.
1910. Becker, G. G., State Plant Board, Little Rock, Ark.
1920. Bedford, Hugh W., Khartoum, Sudan, Africa.
1915. Benjamin, F. H., State Plant Board, Agr. College, Miss. *Noctuidæ, Bombyces.*
1914. Bensel, G. E., Spreckels, Calif.
Ch. Bentley, G. M., 406 Morrill Hall, Univ. Tennessee, Knoxville, Tenn.
1917. Bequaert, Joseph, American Museum Natural History, New York City.
1909. Berger, E. W., State Plant Board, Gainesville, Fla.
1920. Berry, Lulu, Vinton, Iowa.
1913. Bethune-Baker, G. T., 20 Newbold Terrace, Leamington Spa., England.
Ch. Betten, Cornelius, 3 The Circle, Ithaca, N. Y. *Trichoptera.*
1913. Bilsing, S. W., College Station, Texas. Cerambycidæ, Orthoptera.
Ch. Bird, Henry, 600 Milton Road, Rye, N. Y. Noctuidæ–*Papaipema.*
Ch. Bishopp, F. C., Box 208, Dallas, Texas. *Ixodoidea*, Siphonaptera, Anopleura.
1913. Blackman, M. W., N. Y. S. Coll. Forestry, Syracuse, N. Y. *Ipidæ, Cerambycidæ*, Buprestidæ.
1918. Blackmore, E. H., Box 221, Victoria, B. C. Canadian Lepidoptera.
Ch. Blaisdell, F. E. Sr., 1520 Lake Street, San Francisco, Calif. *Tenebrionidæ, Melyridæ, Hydrophilidæ.*
1916. Bliss, C. I., Dept. Zoology, Columbia Univ., New York. *Erythroneura on grape.*
1922. Bourne, Arthur I., 12 E. Pleasant St., Amherst, Mass.
1914. Boving, A. G., U. S. Nat. Mus., Washington, D. C. *Coleopterous larvæ.*
1923. Bowen, W. W., Wellcome Tropical Laboratories, Khartoum, Sudan.
1917. Bowers, H. L., 31 N. Eastfield Ave., Trenton, N. J. Lepidoptera.
1922. Boyd, F. W., Box 1094, Billings, Mont. Orthoptera.
1919. Bradley, George H., Mound, La. Diptera.

1922. Branch, Hazel E., 3756 East Douglas Ave., Wichita, Kansas. Chironomidæ, Trichoptera.
1922. Brannon, Clarence H., Box 299, Charlottesville, Va.
Ch. Braun, Annette F., 2702 May St., Cincinnati, Ohio. *Microlepidoptera.*
1923. Brethes, Dr. Juan, Mar Chiquita, 5033, General Urquiza (F. C. C. A.), Buenos Aires, Rep. Argentina.
1921. Brinley, Floyd J., Japanese Beetle Lab., Riverton, N. J. Ecology.
1914. Brolemann, Henry W., Box 22, Pau, Basses-Pyrenees, France.
1919. Bromley, Stanley W., 17 Phillips St., Amherst, Mass. Asilidæ, Tabanidæ.
Ch. Brooks, Fred E., French Creek, W. Va. Fruit and Nut Insects.
1918. Brundrett, H. M., 702 Carter Bldg., Houston, Texas.
1919. Bryan, Edwin H., Bishop Museum, Honolulu, Hawaii. Hawaiian Diptera.
1917. Buchanan, L. L., U. S. Biol. Survey, Washington, D. C. *Rhynchophora.*
Ch. Bueno, J. R. de la Torre, 11 North Broadway, White Plains, N. Y. Aquatic Hemiptera.
1922. Bulger, Jacob W., Dept. Zoology, Ohio State Univ., Columbus, Ohio.
1912. Burrill, A. C., State Board Agr., Jefferson City, Mo. Ants.
1919. Buys, John L., University of Akron, Akron, Ohio. Homoptera.
1922. Bynum, Eli K., Box 331, Gulfport, Miss.
1917. Calder, Edwin E., Longmeadow, R. I.
1914. Cameron, A. E., Univ. Saskatchewan, Saskatoon, Canada. Diptera.
1913. Campbell, Roy E., 200 S. Third St., Alhambra, Calif. Syrphidæ.
1907. Campos, Francisco R., Mus. Natural History, Guayaquil, Ecuador, Apartado No. 484.
1914. Capp, S. B., Box 2054, Philadelphia, Penn.
1915. Carnochan, Frederic G., New City, Rockland Co., N. Y. Coleoptera.
1917. Carr, Frederick S., 222 Fourth St., S. W., Medicine Hat, Alberta. Coleoptera.
1914. Carter, Henry F., Bacteriological Institute, Colombo, Ceylon.
1922. Carter, Walter, Entomological Lab., Lethbridge, Alta., Canada.
1917. Cartwright, W. B., Box 283, Centralia, Illinois.
1912. Casey, Thomas L., Stoneleigh Court, Washington, D. C.
1918. Caudell, A. N., U. S. Nat. Mus., Washington, D. C. *Orthoptera,* Nearctic Neuroptera.
1914. Chaffee, Mrs. Gertrude B., Amenia, North Dakota.
1922. Chamberlin, Joseph C., Box 878, Stanford Univ., Calif. *Pseudoscorpionida,* Coccidæ.
1917. Chambers, E. L., Office of State Entomologist, Madison, Wis.
1914. Champion, H. G., W. Almora Division, Almora, U. P., India.
1921. Chandler, S. C., 402 W. Walnut St., Carbondale, Ill.
1917. Chapin, Edwin A., Bureau Animal Industry, Washington, D. C. *Cleridæ of world,* Siphonaptera, Mallophaga.
1915. Chapman, James W., Silliman Institute, Dumaguete, Negros, P. I.
1914. Chapman, R. N., Dept. Animal Biology, University Farm, St. Paul, Minn.
1917. Chermock, Hugo L., 1308 Tell St., North Side, Pittsburgh, Pa.
1913. Childs, Leroy, Hood River, Oregon.
1918. Claassen, P. W., 102 Irving Place, Ithaca, New York. *Plecoptera.*
1914. Clausen, Curtis P., 2900 Negishi-macpi, Yokahama, Japan. Chalcidoidea, Proctotrypoidea.

1910. Clemens, Mrs. Wilburt A., Dept. Biology, Univ. Toronto, Toronto, Canada.
1917. Coad, B. R., Tallulah, La.
1917. Cole, Charles J., Elkins Park, Penna.
1916. Cole, Frank R., Box 177, Redlands, Calif. Hymenoptera, *Diptera.*
1916. Collins, C. W., Gipsy Moth Lab., Melrose Highlands, Mass. *Calosoma.*
1921. Colman, Wallace, 121 Russell Aye., Ames, Iowa. Diptera.
1921. Compton, C. C., Box 12, Aurora, Ill.
Ch. Cook, Mel T., Experiment Station, Rio Piedras, P. R. Insect Galls.
1919. Cook, William C., Montana State Coll., Bozeman, Mont. *Noctuidæ.*
1910. Cooley, R. A., Montana State Coll., Bozeman, Mont. Coccidæ.
1916. Corcoran, J. A., Loyola College, Montreal, Quebec.
1921. Costa-Lima, Angelo M., Gabinete de Entomologia, Escola Superior de Agricultura Fonseca, Nictheroy (E. do Rio), Brasil. Nycteribiidæ, Cicadidæ.
1915. Cotton, Richard T., U. S. Bur. Entomology, Washington, D. C. *Larvæ of Calandridæ.*
1921. Cowles, Raymond B., 116 Oak Ave., Ithaca, N. Y. Coleoptera, Diptera.
1921. Craighead, Eugene M., Bur. Plant Ind., Harrisburg, Pa. Chrysomelidæ, Siphonaptera.
Ch. Crawford, J. C., 1616 H. St., N. W., Washington, D. C.
1912. Creel, Cecil W., Univ. of Nevada, Reno, Nevada.
Ch. Cresson, E. T. Jr., 11 Amherst Ave., Swarthmore, Pa. Acalyptrate Diptera, *Ephydridæ.*
Ch. Criddle, Norman, Treesbank, Manitoba. Orthoptera, Coleoptera.
Ch. Crosby, C. R., Roberts Hall, Ithaca, N. Y. Spiders.
1914. Crossman, S. S., 17 E. Highland Ave., Melrose Highlands, Mass. Parasitic Hymenoptera.
1915. Curran, C. H., Orillia, Ontario, Canada.
1921. Cutright, C. R., Ohio Agr. Exp. Station, Wooster, Ohio. Aphiidæ.
1914. Dalglish, A. A., 7 Keir St., Pollokshields, Glasgow, Scotland.
1913. Davidson, W. M., Vienna, Va. Syrphidæ.
1922. Davis, Edgar W., Box 438, State Agr. Coll., Manhattan, Kansas.
1914. De Gryse, Joseph J., Charlottesville, Va.
1914. De Long, D. M., Dept. Zoology, Ohio State Univ., Columbus, Ohio. *Cicadellidæ,* Fulgoridæ, Membracidæ.
1919. Detwiler, John D., 693 Queen's Ave., London, Ontario, Canada.
Ch. Dickerson, Edgar L., 106 Prospect St., Nutley, N. J. Homoptera.
1922. Dietrich, Henry, Appleton, N. Y. *Coleoptera.*
1913. Dietz, H. F., 3225 Boulevard Pl., Indianapolis, Ind.
Ch. Dietz, Wm. G., 21 N. Vine St., Hazelton, Pa.
Ch. Doane, R. W., Stanford University, Calif.
1922. Dodds, Clifford T., 201 Agriculture Hall, Univ. Calif., Berkeley, Calif. Callimonidæ.
1922. Doering, Kathleen C., 1214 Tennessee St., Lawrence, Kans. Cercopidæ.
1914. Dognin, Paul, Demt. a Les Pipots, Rue Wimille (Pas-de-Calais), Paris, France.
1922. Dohanian, S. M., 17 E. Highland Ave., Melrose Highlands, 77, Mass.
Ch. Doten, S. B., Experiment Station, Reno, Nevada.

1922. DOUCETTE, CHARLES F., Greenhouse Insect Lab., Willow Grove, Pa. Greenhouse Insects.
1917. DOWELL, PHILIP, 86 Bond St., Port Richmond, N. Y.
1922. DOWDEN, P. B., Sandwich, Mass.
1922. DRAKE, CARL J., Iowa State College, Ames, Iowa. Tingitidæ.
1919. DUNN, MARIN S., 4746 Hazel Ave., Philadelphia, Pa. Diptera, Lepidoptera.
1916. DU PORTE, E. MELVILLE, Macdonald College, Quebec. Diptera, Ixodoidea.
1917. DURAN, VICTOR, 1554 S. Wilton Place, Los Angeles, Calif.
1914. DUSHAM, E. H., College Heights, State College, Pa. Coleoptera.
Ch. EASTON, NORMAN, 458 Hight St., Fall River, Mass. Coleoptera.
1913. EDMONSTON, W. D., Box 1658, Tucson, Arizona. Forest Entomology.
Ch. EDWARDS, EDWIN H., 7317 Clinton Ave., Cleveland, Ohio. Coleoptera.
Ch. EHRHORN, EDW. M., Box 2520, Honolulu, Hawaii.
1913. ELLIS, WILLIAM O., 10 Court St., Arlington, Mass.
1917. ELROD, M. J., Missoula, Mont.
1911. ELY, CHARLES R., 6 Kendall Green, Washington, D. C. Gracilariidæ.
1919. EMERSON, ALFRED, Dept. of Zoology, Univ. Pittsburgh, Pittsburgh, Pa. *Termites.*
1922. EMERY, GEORGE, 249 Lakeside Ave., Marlboro, Mass.
1914. ENBURG, JOHN M., 5207 Baltimore Ave., Philadelphia, Pa.
Ch. ENGELHARDT, GEORGE P., Museum, Eastern Parkway, Brooklyn, N. Y. Aegeriidæ.
1922. ESAKI, TEISO, Ento. Lab., Coll. Agr., Kiushiu, Imperial Univ., Fukukoa, Japan. Heteroptera.
1910. ESSIG, E. O., Room 201 A. H., Univ. Calif., Berkeley, Calif. *Aphididæ,* Coccidæ.
1914. EVENDEN, JAMES L., Coeur d'Alene, Idaho. Forest Entomology.
Ch. EWERS, WILLIAM V., 44 N. Goodman St., Rochester, N. Y. Diptera.
1910. EWING, H. E., U. S. Nat. Museum, Washington, D. C. Acarina-Protura-Mallophaga-Arachnida-Anoplura-Siphonaptera.
1918. EYER, JOHN R., Univ. Club, State College, Pa.
1917. FACKLER, HARRY L., State Entomologist's Office, Knoxville, Tenn.
1917. FATTIG, P. W., 207 Pine St., Farmville, Va.
1923. FAZ, ALFREDO, Bandera No. 714, Santiago, Chile, South America.
1915. FENTON, F. A., Dept. Entomology, State Coll., Ames, Iowa. Anteoninæ.
1914. FERRIS, G. F., Stanford Univ., Calif. Coccidæ, ectoparasites.
Ch. FIELD, W. L. W., Milton Academy, Milton, Mass. Lepidoptera, Orthoptera.
1922. FILINGER, George A., Box 6, Kansas State Agr. Coll., Manhattan, Kansas.
1910. FINK, D. E., Riverton, N. J.
1907. FISHER, W. S., U. S. Nat. Mus., Washington, D. C. *Buprestidæ*; *Cerambycidæ.*
1922. FLEMING, ANDREW, Sibley, Adams Co., Miss.
1922. FLETCHER, FRANK C., 2816 W. 44th St., Minneapolis, Minn. Coleoptera, Tenebrionidæ.
1919. FLETCHER, ROBERT K., College Station, Texas. Heteroptera.
1908. FLINT, W. P., Natural History Bldg., Urbana, Ill.
1919. FLORENCE, LAURA, Box 284, Princeton, N. J. Siphunculata.
1908. FORBES, WILLIAM T. M., 23 Trowbridge Road, Worcester, Mass. Lepidoptera of *Northeastern States.*

1922. FORD, NORMA, 96 Dunn Ave., Toronto, Ontario, Canada.
1916. FORTUN, GONZOLA M., Calle 9, No. 5, Santiago de las Vegas, Cuba.
1919. FOURNIER, MRS. GASTON, 90 Boulevard, Malesherbes, Paris (8) France. Lepidoptera.
1912. FOX, HENRY, Mercer Univ., Macon, Ga. *Orthoptera*, Cicindelidæ, Scarabaeidæ.
1911. FRACKER, S. B., State Capitol, Madison, Wis. Coreidæ.
1922. FRANCE, L. V., University Farm, St. Paul, Minn. Apiculture.
1918. FRANK, ARTHUR, Puyallup, Wash.
1922. FRIEND, ROGER B., 23 Ashmont St., Dorchester, Mass. Diptera, Hymenoptera, Hemiptera.
1914. FRISON, T. H., Nat. Hist. Bldg., Urbana, Ill. *Bremidæ.*
Ch. FROST, C. A., 67 Henry St., Framingham, Mass. *Coleoptera.*
1914. FROST, S. W., Arendtsville, Pa. *Phytomyza*, Agromyzidæ.
Ch. FULLAWAY, D. T., 1430 Kewalo St., Honolulu, Hawaii. Hymenoptera. Braconidæ.
1916. FULTON, B. B., Oregon Agric. Coll., Corvallis, Oregon. Orthoptera.
Ch. GAHAN, A. B., Berwyn, Md. Chalcidoidea, Braconidæ.
1916. GAIGE, FREDERICK M., Museum of Zoology, Univ. Mich., Ann Arbor, Mich. *Formicidæ.*
1922. GARLICK, W. GILBERT, 302 Museum, Univ. Kansas, Lawrence, Kansas. Tethhredinoidea.
1914. GARMAN, PHILIP, Conn. Agr. Exp. Sta., New Haven, Conn. *Odonata*, Acarina.
1917. GARNETT, R. T. DE, 583 Merrimac St., Oakland, Calif. *Buprestidæ*, *Cicindelidæ.*
1918. GARRISON, G. F., Bureau of Entomology, Washington, D. C.
1922. GEHRING, JOHN GEORGE, Bethel, Maine.
1916. GENTNER, LOUIS G., 213 Bailey St., East Lansing, Mich. *Halticini.*
Ch. GERHARD, WM. J., Field Mus. Nat. Hist., Chicago, Ill. Hemiptera.
1922. GERRY, BERTRAM, 7 Howard Ave., Peabody, Mass. Diptera, Coleoptera.
1912. GIBSON, E. H., R. D. No. 1, Alexandria, Va.
1913. GIBSON, FRANK M., 235 W. Lafayette Ave., Baltimore, Md. Lepidoptera.
Ch. GIFFARD, W. M., Box 308, Honolulu, Hawaii.
1922. GILMER, PAUL M., Div. of Ento., Univ. Farm, St. Paul, Minn.
1916. GLASER, RUDOLF W., Rockefeller Inst. for Medical Research, Princeton, N. J. Pathology of Insects.
1911. GLASGOW, HUGH, Experiment Station, Geneva, N. Y.
1911. GLASGOW, ROBERT D., Nat. Hist. Bldg., Urbana, Ill. *Phyllophaga.*
1919. GLICK, PERRY A., State Entomological Bldg., Phoenix, Arizona.
1916. GOOD, A. I., 3485 Townsend Ave., Detroit, Mich.
1921. GOOD, HENRY G., Dept. Ento., Cornell Univ., Ithaca, N. Y., Coleoptera.
1908. GOODWIN, W. H., Wooster, Ohio.
Ch. GOSSARD, H. A., Agric. Exp. Sta., Wooster, Ohio. Orthoptera, Hemiptera.
Ch. GRAENICHER, SIGMUND, Box 14, Larkins, Fla. Aculeate Hymenoptera; Muscoid Diptera.
1917. GRAHAM, SAMUEL A., Univ. Farm, St. Paul, Minn. Scolytidæ-Cerambycidæ-Buprestidæ.

1922. GRANOVSKY, ALEXANDER A., 1532 University Ave., Madison, Wis. Aphididæ.
1914. GREENE, CHARLES T., Box 51, East Falls Church, Va.
1917. GRINNELL, FORDYCE, Hilo, Hawaii.
1919. GRISWOLD, GRACE H., 126 Roberts Place, Ithaca, N. Y.
1914. GUBERLET, JOHN E., A. & M. Coll., Stillwater, Okla.
1913. GUNN, DAVID, Box 597, Port Elizabeth, S. Africa.
1916. GUYTON, T. L., Bur. of Plant Ind., Dept. of Agr., Harrisburg, Pa.
1921. GUYTON, F. E., Auburn, Ala. Blattidæ.
1916. HADWEN, S., U. S. Biological Survey, Washington, D. C.
1914. HAGAN, HAROLD R., Univ. Utah, Salt Lake City, Utah. Diptera.
1922. HALL, MAURICE C., Zoological Div. Bur. An. Ind., Washington, D. C. Parasites of domestic animals.
1921. HALLOCK, HAROLD C., Weatherly, Pa. Diptera.
1914. HALLINEN, J. E., Cooperton, Kiowa Co., Oklahoma.
1914. HAMILTON, C. C., Univ. Md., College Park, Md. Larvæ of *Cicindelidæ* and *Carabidæ*.
1916. HAMLIN, JOHN C., Box 509, Uvalde, Texas. *Membracidæ*, Homoptera.
1922. HAMNER, A. L., Box 1252, Auburn, Ala. Aphididæ.
Ch. HANSEN, JAMES, St. John's Univ., Collegeville, Minn.
1922. HARINGTON, R. J., 86 Pleasant St., Amherst, Mass.
1907. HARNED, R. W., State Plant Board, Agricultural College, Miss.
1922. HARTLEY, EDWIN A., N. Y. State Coll. of Forestry, Syracuse, N. Y. Parasitic Hymenoptera.
1920. HARTZELL, ALBERT, Dept. Entom., Agr. Exp. Station, Geneva, N. Y. *Empoasca;* Orgerini.
1907. HARTZELL, FREDERICK Z., 321 W. Main St., Fredonia, N. Y. Coleoptera.
1921. HARWOOD, R. D., Claremont, Calif.
Ch. HASEMAN, L., Univ. of Missouri, Columbia, Mo.
1919. HATCH, MELVILLE H., Zoology Dept., Univ. Mich., Ann Arbor, Mich. *Histeridæ, Silphidæ.*
1919. HAYES, WM. P., Kans. State Agr. Coll., Manhattan, Kansas.
1923. HERBST, PAUL, Casilla 3528, Valparaiso, Chile. Hymenoptera.
1920. HERTIG, MARSHALL, Dept. Animal Biol., Univ. Minn., Minneapolis, Minn. Insect Symbionts.
1916. HESS, WALTER N., De Pauw Univ., Greencastle, Ind.
1908. HEYWOOD, MRS. R. S., Webster City, Iowa.
1919. HILL, C. C., U. S. Entom. Lab., Carlisle, Pa. Embryology and ecology of Hymenoptera.
1908. HILTON, W. A., Claremont, Calif.
Ch. HINDS, W. E., Ala. Exper. Sta., Auburn, Ala.
Ch. HODGKISS, H. E., Botany Bldg., State College, Pa. Eriophyidæ.
1917. HOFER, GEO., Entom. Ranger, Box 1658, Tucson, Arizona. Forest Insects.
1914. HOFFMAN, WM. A., Johns Hopkins Univ., Baltimore, Md.
1919. HOFFMAN, WILLIAM E., Div. of Entom., Univ. Farm, St. Paul, Minn. *Aquatic Heteroptera.*
1919. HOKE, GLADYS, 1104 M Street, N. W., Washington, D. C. *Coccidæ.*
1913. HOLLOWAY, T. E., Sugar Expt. Sta., Audubon Park, New Orleans, La.
1912. HOOD, C. E., Melrose Highlands, Mass.

Ch. HOOD, J. D., 104 Chestnut St., Rochester, N. Y.
1913. HORTON, JOHN R., 126 S. Minneapolis Ave., Wichita, Kans. *Phyllophaga.* Thysanoptera.
Ch. HOUSER, J. S., Ohio Agr. Exp. Sta., Wooster, Ohio. Coccidæ.
Ch. HOWARD, CHARLES T., 1735 East Ave., Rochester, N. Y. Lepidoptera.
1907. HOWARD, CHAS. W., Christian College, Canton, China.
1914. HOWARD, NEALE F., Drawer E, Woodlawn P. O., Birmingham, Ala.
1917. HOWE, R. HEBER, JR., 58 Highland St., Cambridge, Mass. Odonata.
1914. HOWES, GEORGE, 432 George St., Dunedin, New Zealand. Ephemeridæ.
Ch. HUARD, V. A., 2 Richelieu St., Quebec, Canada. Lepidoptera.
1921. HUBER, L. L., 111 E. Main St., Geneva, Ohio. Chalcidoidea.
1921. HUCKETT, H. C., Box 152, Riverhead L. I., N. Y. *Anthomyiinæ.*
1922. HULL, FRANK M., Dept. Entom., Ohio State Univ., Columbus, Ohio. *Syrphidæ, Stratiomyidæ, Tabanidæ.*
1909. HUNGATE, J. W., State Normal School, Cheney, Wash.
1916. HUNGERFORD, H. B., Dept. Entom., Lawrence, Kansas. *Corixidæ, Nepidæ, Notonectidæ, Hydrometridæ,* Aquatic Hemiptera.
Ch. HUNTER, W. D., Carter Bldg., Houston, Texas.
1917. HUSSEY, ROLAND F., Bussey Institution, Boston 30, Mass. *Hemiptera.*
1908. HYSLOP, J. A., Bureau of Entomology, Washington, D. C. Elateridæ.
1911. ILLINGWORTH, J. F., Meringa near Cairns, North Queensland, Australia.
1914. ISELY, DWIGHT, Agr. Exp. Sta., Fayetteville, Ark. Eumenidæ.
1922. ISHIMORI, NAOTO, Ueda, Shinano, Japan. Lepidoptera.
1907. JACKSON, C. F., Durham, N. H. Ecology.
1915. JACKSON, L. O., 317 E. Carr Ave., Cripple Creek, Colo. *Aphilanthops.*
1920. JAQUES, H. E., Mt. Pleasant, Iowa. Phyllophaga.
1910. JENNINGS, H. R., Lowell High School, San Francisco, Calif.
1915. JEWETT, H. H., R. R. No. 2, Lexington, Ky.
Ch. JOHNSON, S. A., 612 Elizabeth St., Fort Collins, Colo.
1917. JONES, C. R., Colo. Agric. Coll., Fort Collins, Colo.
Ch. JONES, FRANK M., 2000 Riverview Ave., Wilmington, Delaware. *Psychidæ.*
1916. KAHL, HUGO, Carnegie Mus., Pittsburgh, Pa. Odonata.
1921. KEEN, SADIE E., Drawer J., Forest Grove, Ore. Cereal and Forage Insects.
Ch. KELLER, GEORGE J., 68 Treacy Ave., Newark, N. J. Catocalæ.
1914. KENNEDY, CLARENCE H., Entom. Dept., Ohio State University, Columbus, Ohio. Odonata.
1921. KESSEL, MRS. QUINTA CATTELL, Garrison, N. Y.
Ch. KINCAID, TREVOR, Univ. Washington, Seattle, Wash. *Psychodidæ.* Tenthredinoidea.
1914. KING, H. H., Wellcome Tropical Research Lab., Khartoum, Anglo-Egyptian Sudan, S. Africa.
1912. KING, J. L., 3233 Carnegie Ave., Cleveland, Ohio. Tachinidæ of Japan.
1923. KING, KENNETH M., Univ. Saskatchewan, Saskatoon, Sask., Canada.
1919. KING, ROBERT L., Zool. Lab., Univ. Pa., Philadelphia, Pa. Orthoptera.
1918. KINSEY, ALFRED C., 620 S. Fess St., Bloomington, Ind. *Cynipidæ.*
1916. KISLIUK, MAX, JR., 134 S. Second St., Philadelphia, Pa. Muscidæ.
1920. KNAPP, MRS. CHARLES M., 437 Waverly Ave., Syracuse, N. Y.
1911. KNIGHT, HARRY H., Univ. Farm, St. Paul, Minn. Heteroptera, *Miridæ.*
1922. KNIGHT, PAUL, Dept. Entom., Urbana, Ill.

Ch. KOTINSKY, JACOB, 5154 Parkside Ave., Philadelphia, Pa. Adelginæ (Chermes).
1917. KRAATZ, WALTER C., Zoology Bldg., Ohio State Univ., Columbus, Ohio.
1914. LAAKE, E. W., Box 208, Dallas, Texas. Diptera.
1922. LACKEY, JAMES, 146 Waycaster Pl., Jackson, Miss. Coleoptera.
1919. LACROIX, DON, 90 Pleasant St., Amherst, Mass.
Ch. LAGAI, GEORGE, 440 Bedford Ave., Richmond Hill, L. I., N. Y.
1919. LAMBERT, FLOYD, 4321 Walnut St., Philadelphia, Pa.
1912. LAMKEY, ERNEST M. R., Agr. Exp. Sta., Newark, Delaware.
1917. LANE, M. C., Box 498, Ritzville, Wash.
Ch. LANG, JOSEPH N., 1433 S. 59th Ave., Cicero, Ill.
1917. LANGE, RICH. C., U. S. Entom. Lab., 628 Yeddo Ave., Webster Groves, Mo. Catocala.
1917. LANGSTON, J. M., A. & M. College, Miss. Phyllophaga.
1914. LARRIMER, W. H., Box 95, W. Lafayette, Ind. *Cicadellidæ.*
1913. LATHROP, FRANK H., Experiment Station, Geneva, N. Y. Cicadellidæ.
1919. LATHY, PERCY I., 90 Bd. Malesherbes, Paris, France. Lepidoptera.
Ch. LAURENT, PHILIP, 31 E. Mt. Airy Ave., Philadelphia, Pa.
1917. LAWSON, PAUL B., 605 Maine St., Lawrence, Kansas. Homoptera, *Cicadellidæ.*
1922. LEARNED, ELMER T., 46 Franklin St., Fall River, Mass. Lepidoptera, Arctiidæ.
1912. LEIBY, R. W., State Dept. Agric., Raleigh, N. C. Insect Polyembryony.
Ch. LILJEBLAD, E., 1018 Roscoe St., Chicago, Ill.
1917. LINDSEY, A. W., Box 782, Granville, Ohio. *Hesperioidea of world; Pterophoridæ of N. A.*
1914. LITTLER, FRANK M., Box 114, Lanneeston, Tasmania, Australia.
Ch. LLOYD, J. T., 34 Walnut Ave., Wyoming, Hamilton Co., Ohio.
Ch. LOCHHEAD, W., Macdonald College, Quebec, Canada.
1919. LOCKWOOD, STEWART, Box 1094, Billings, Mont. Orthoptera.
1922. LOUNSBURY, CHARLES P., Box 513, Pretoria, S. Afr.
1917. LOVETT, A. L., Agric. Coll., Corvallis, Oregon.
1919. LOWRY, P. R., New Hampshire Coll., Durham, N. H. *Coccidæ, Mealy Bugs.*
1913. LUGINBILL, PHILIP, U. S. Entom. Sta., Columbia, S. C. Phyllophaga.
1917. LUNDBECK, WM., Zoological Museum, Copenhagen, Denmark. Diptera.
1922. LUTKEN, ALFRED, Logtown, Miss.
1914. MCATEE, W. L., Biolo. Sur., U. S. Dept. Agric., Washington, D. C. *Heteroptera, Homoptera, Diptera.*
1920. MCBRIDE, O. C., Whitten Hall, Columbia, Mo.
1917. MCCOLLOCH, JAMES W., Agric. Exp. Sta., Manhattan, Kans. *Scarabaeidæ, Tenebrionidæ.*
1907. MCCRACKEN, MISS ISABEL, Stanford Univ., Calif., Box 44. *Cynipidæ,* Apoidea.
1910. MCDANIEL, EUGENIA, I., Agric. Coll., East Lansing, Mich.
1911. MCINDOO, N. E., Bur. Entom., Washington, D. C. Insect Physiology.
1919. MCMAHON, ARTHUR, 9 Dalhousie St., Montreal, Canada. Hymenoptera.
1921. MCNEILL, JEROME, Thonotosassa, Fla. Orthoptera.
1917. MAHEUX, GEO., Parliament Bldg., Quebec, Canada.

1922. MANK, EDITH W., 12 Reservoir St., Lawrence, Mass. Coleoptera.
1921. MANK, HELEN GARDNER, 12 Reservoir St., Lawrence, Mass.
Ch. MANN, B. PICKMAN, 1918 Sunderland Place, Washington, D. C.
1913. MANN, WILLIAM M., U. S. Nat. Mus., Washington, D. C. *Formicidæ, Ant Guests, Termitophiles.*
1922. MARCOVITCH, SIMON, Univ. Tenn., Knoxville, Tenn.
1921. MASON, ARTHUR C., Box 576, Lindsay, Calif. Thrips.
1912. MASON, P. W., U. S. Bur. Entom., Washington, D. C. *Aphiidæ.*
1916. MASON, SHIRLEY L., 5554 Avondale Place, Pittsburgh, Pa.
Ch. MATHESON, ROBERT, Cornell Univ., Ithaca, N. Y. *Ixodoidea, Culicidæ,* Parasitic Insects.
1917. MAY, RAOUL M., 106 Hammond St., Cambridge, Mass.
1909. MATCALF, Z. P., State College Sta., Raleigh, N. C. Homoptera.
1917. MICKEL, CLARENCE E., Box 417, Rocky Ford, Colo. Sphecoidea, Mutillidæ.
1922. MIDDLETON, WILLIAM, Bur. of Entom., Washington, D. C. Chalastogastrous larvæ.
1921. MILLER, AUGUST E., Care of Ross County Farm Bureau, Chillicothe, Ohio. Mites.
Ch. MILLER, ELLEN ROBERTS, 115 W. High St., Painesville, Ohio.
1921. MITCHELL, THEO. B., State Dept. Agric., Raleigh, N. C. Apoidea.
1921. MOFFATT, ELIZABETH M., Wheaton, Ill. *Araneida.*
1922. MONTGOMERY, BASIL E., Poseyville, Ind. Coleoptera, Lepidoptera.
1908. MOORE, WILLIAM, American Cyanimid Co., 511 Fifth Ave., New York.
1923. MOREIRA, CARLOS, Rau Sta. Clara 26, Copacabana, Rio de Janeiro, Brazil.
1908. MORGAN, ANN H., South Hadley, Mass. Ephemeridæ.
Ch. MORGAN, H. A., Univ. of Tenn., Knoxville, Tenn.
Ch. MORRILL, A. W., 382 W. Ave., 53, Los Angeles, Calif. Aleyrodidæ.
1917. MORRIS, FRANCIS J. A., 643 Aylmer St., Peterborough, Ont., Canada.
1922. MORRIS, WALTER MARKLEY, 44 Triangle St., Amherst, Mass.
1912. MORRISON, HAROLD, Federal Horticultural Board, Washington, D. C.
1914. MOSELEY, MARTIN E., 94 Campden Hill Road, Kensington, London, Eng. Trichoptera, Ephemeridæ, Plecoptera, Scent Organs.
Ch. MOSHER, F. H., 17 E. Highland Ave., Melrose Highlands, Mass.
1920. MOTE, DON C., Box 348, Phoenix, Arizona.
1915. MUSEBECK, C. F. W., 17 E. Highland Ave., Melrose Highlands, Mass. Braconidæ, *Microgasterinæ, Meteorinæ.*
1917. MUTCHLER, ANDREW J., Amer. Mus. Nat. Hist., New York City. Lampyridæ.
1915. MUTTKOWSKI, R. A., Univ. of Idaho, Moscow, Idaho. Aquatic Insects.
1907. MYERS, P. R., U. S. Entom. Lab., Carlisle, Pa.
1921. NAUDE, T. J., Botany-Zoology Bldg., Columbus, Ohio. Cicadellidæ.
1912. NEILLIE, CHAS. R., 4317 E. 116th St., Cleveland, Ohio.
1921. NEILSON, ERNEST, Care of Chris E. Olsen, Amer. Mus. Nat. Hist., New York City.
1921. NEISWANDER, C. R., Dept. Entom., Ohio State Univ., Columbus, Ohio.
1907. NELSON, Jos. A., Route 3, Mt. Vernon, Ohio.
Ch. NESS, H., 821 Kellogg Ave., Ames, Ia.

Ch. NEWCOMB, W. W., 90 Webb Ave., Detroit, Mich. Lycaenidæ, Notodontidæ, Noctuidæ.
Ch. NEWCOMER, E. J., Box 243, Yakima, Wash. Thysanoptera.
1907. NEWELL, WILMON, Agric. Exp. Sta., Gainesville, Fla.
1915. NEWMAN, GEORGE B., Univ. Club, State College, Pa.
1919. NININGER, H. H., 310 College St., Winfield, Kansas.
1922. NOBLE, W. B., Box 95, W. Lafayette, Ind.
1917. NOTMAN, HOWARD, 136 Joralemon St., Brooklyn, N. Y. *Carabidæ*, Staphylinidæ, *Stenus*.
1908. O'KANE, W. C., State College, Durham, New Hampshire.
1916. OLSEN, CHRIS E., Amer. Mus. of Nat. Hist., New York City. Cicadellinæ.
1908. OSBORN, H. T., H. S. P. A. Exper. Sta., Honolulu, Hawaii.
Ch. OSLAR, ERNEST J., Denver, Colo., 4535 Raleigh St.
1920. OTANES, FAUSTINO Q., Bureau of Agric., Manila, Philippine Islands.
1917. OUELLET, JOSEPH, 1145 St. Viateur St., Outremont, Quebec.
1915. PACKARD, C. M., 600 Twenty-sixth St., Sacramento, Calif.
1913. PADDOCK, F. B., Sta. A., Ames, Iowa. Apiculture.
1918. PAINTER, H. R., U. S. Entom. Lab., Box 95, W. Lafayette, Ind. Orthoptera.
1919. PAINTER, REGINALD H., Address unknown.
1918. PARKER, J. B., 1217 Lawrence St., N. E., Washington, D. C. Bembecidæ.
1916. PARKER, R. R., Hamilton, Mont. *Sarcophagidæ*.
1916. PARKS, H. B., Box 838, San Antonio, Texas. Apiculture.
1918. PARKS, T. H., Ohio State Univ., Columbus, Ohio.
1912. PARSHLEY, H. M., Smith College, Northampton, Mass. Heteroptera.
Ch. PAXSON, OWEN S., Radnor, Delaware Co., Pa.
1919. PEAIRS, L. M., Morgantown, W. Va. Mallophaga, Thysanoptera.
1920. PEARSON, GEORGE B., Box 95, W. Lafayette, Ind. Buprestidæ.
1922. PEARSON, JOHN C., 116 Pleasant St., Amherst, Mass.
1911. PETERSON, ALVAH, Rutgers College, New Brunswick, N. J. Diptera.
1907. PETRUNKEVITCH, ALEXANDER, Osborn Zool. Lab., Yale Univ., New Haven, Conn. Arachnida.
Ch. PETTIT, R. H., Agric. Exper. Sta., East Lansing, Mich. Coccidæ.
1921. PHILLIPS, E. F., Bureau of Entom., Washington, D. C. Apiculture.
1912. PHILLIPS, W. J., U. S. Entom. Lab., Box 299, Charlottesville, Va. *Harmolita*.
Ch. PIERCE, W. DWIGHT, San Mateo, Calif. Rhynchophora, *Strepsiptera*.
1913. POOS, FRED W., Care of European Corn Borer Lab., Sandusky, Ohio. *Harmolita, Bombidæ*.
1918. POPE, THOMAS E. B., Public Museum, Milwaukee, Wis.
1921. POTGIETER, JOHANNES, Box 32, Zastrom, O. F. S., S. Africa.
Ch. POWELL, P. B., Clinton, N. Y.
1915. POWERS, EDWIN BOOTH, Univ. of Tennessee, College Medicine, Memphis, Tenn.
1916. PRICE, W. A., Purdue Univ., Lafayette, Ind.
1916. PSOTA, FRANK J., 4046 W. 26th St., Chicago, Ill. Cetonidæ.
Ch. RAMSDEN, CHAS. T., Apartado 146, Guantanamo, Cuba. Lepidoptera, *Sphingidæ*.
1923. RANDOLPH, ABRAHAM M., Casilla 1, Valdivia, Chile, S. Amer.

1913. Rau, Phil, 2819 S. Kingshighway Blvd., St. Louis, Mo. Aculeate Hymenoptera.
1923. Reed, William D., Ent.-Zool., Clemson College, S. C.
1922. Reed, W. V., State Capitol, Atlanta, Ga. Insects of Ornamental Plantings.
1919. Reeher, Max M., Forest Grove, Oregon. Cereal and Forage Insects.
1908. Regan, W. S., Montana State Coll., Bozeman, Mont. Psammocharidæ.
1917. Reis, Jacob A., Jr., Edea, Cameroun, West Africa.
1921. Remy, T. P., Box 225, College Station, Texas.
1918. Ressler, I. L., Dept. Entom., Iowa State Coll., Ames, Iowa.
1914. Richardson, Charles H., Bureau of Entomology, Washington, D. C. Insect Physiology.
1922. Ries, Donald T., 401 Thurston Ave., Ithaca, N. Y. Hymenoptera.
1914. Ris, F., Rheinau, Canton Zurich, Switzerland.
1922. Roberts, H. E., U. S. Entom. Lab., Webster Groves, Mo. Rhyncophora.
1915. Robinson, J. M., Box 264, Auburn, Ala. Coccidæ, Coleoptera.
1913. Rockwood, L. P., Forest Grove, Ore.
1922. Rodriguez, Mauro G., State Coll., Bozeman, Mont. Tropical Insects.
1915. Rogers, J. Speed, Univ. Florida, Gainesville, Fla. Tipuloidea, *Erioptera*.
1922. Root, Francis M., School Hyg. & Pub. Health, 310 W. Monument St., Baltimore, Md. Diptera, *Anopheles*.
1914. Rosenfeld, Arthur H., 2142 Sixteenth Ave., S., Birmingham, Ala.
1912. Ross, William A., Dominion Entom. Lab., Vineland Sta., Ontario. *Aphididæ*.
1921. Rowley, R. R., 1115 N. C. St., Louisiana, Mo. *Catocala*, *Sphingidæ*, *Nymphalidæ*.
1914. Ruckes, Herbert, 1171 Sherman Ave., New York City.
Ch. Ruggles, A. G., University Farm, St. Paul, Minn.
Ch. Rumsey, W. E., Agric. Exp. Sta., Morgantown, W. Va.
1922. Sampson, Howard, Osborn Zool. Lab., New Haven, Conn. Parasitic Insects.
1907. Sanders, G. E., Entom. Lab., Annapolis Royal, N. S., Canada.
Ch. Sasscer, E. R., 1225 Decatur St., N. W., Washington, D. C. Coccidæ.
1907. Satterthwait, Alfred F., U. S. Entom. Lab., Webster Groves, Mo. Calandra.
1922. Schaffer, C. H., Box 5, Agric. Coll., Amherst, Mass.
1919. Schmieder, Rudolf G., 4351 Pechin St., Philadelphia, Pa.
Ch. Schoene, W. J., Agric. Exp. Sta., Blacksburg, Va.
1919. Schwarz, Fred, 4323 Tennessee Ave., St. Louis, Mo.
1910. Scott, E. W., Rockville, Md.
1923. Seamon, Harold L., Canadian Dept. Agric., Dom. Exp. Farm, Lethridge, Alberta.
1922. Sellers, Wendell, 90 Pleasant St., Amherst, Mass.
1908. Severin, H. C., State Coll., Brookings, S. D. Orthoptera, Heteroptera.
1907. Shafer, Geo. D., 321 Melville Ave., Palo Alto, Calif.
1919. Shannon, Raymond C., U. S. Nat. Mus., Washington, D. C.
1922. Shepard, Harold H., 86 Pleasant St., Amherst, Mass. *Hesperiidæ*.
1917. Sherman, Franklin, State Dept. Agric., Raleigh, N. C. Carabidæ, Cicindelidæ, Cerambycidæ.
1911. Sherman, John D., Jr., 132 Primrose Ave., Mt. Vernon, N. Y.

Ch. SHULL, A. FRANKLIN, 520 Linden St., Ann Arbor, Mich. Aphids, Thysanoptera, Whiteflies.
1919. SIBLEY, CHARLES K., Dept. Entom., Cornell Univ., Ithaca, N. Y. *Trichoptera*, Leptoceridæ, Neuropteroids.
Ch. SMITH, JAMES A., 401 Lenox Ave., Westfield, N. J.
1922. SMITH, L. B., U. S. Dept. Agric., Riverton, N. J.
1919. SMITH, MARION R., Agric. College, Miss.
1918. SMITH, RALPH H., 425 Battery St., San Francisco, Calif.
1914. SMITH, ROGER C., Agric. Coll., Manhattan, Kans. Neuropteroids, *Chrysopidæ*.
1914. SMULYAN, MARCUS T., U. S. Bur. Entom., Melrose Highlands, Mass. Tenthredinidæ, *Tenthredella*.
Ch. SMYTH, ELLISON A., JR., Va. Poly. Inst., Blacksburg, Va. *Papilio*, *Sphingidæ*.
1918. SNAPP, OLIVER I., U. S. Bur. Entom., Fort Valley, Ga. Rhynchophora, Conotrachelus.
1922. SNYDER, THOMAS E., U. S. Bur. Entom., Washington, D. C. Isoptera.
1914. SPENCER, G. J., O. A. College, Guelph, Ont., Canada. Trypetidæ.
1919. SPENCER, HERBERT, Va. Truck Exp. Sta., Norfolk, Va. Hymenoptera.
1921. SPENCER, ROBERT D., Ashland State Hospital, Ashland, Pa. Diptera.
Ch. SPOONER, CHARLES S., 1436 Seventh St., Charleston, Ill. Hemiptera.
1922. SPULER, ANTHONY, 611 Michigan Ave., Pullman, Wash. Diptera, Barboridæ.
1910. STAFFORD, E. W., Agric. College, Miss. Acalyptrate Muscoids.
1917. STAHL, C. F., Care of Citrus Exp. Sta., Riverside, Calif.
1919. STEAR, J. R., 406 N. Third St., Harrisburg, Pa. Miridæ.
1917. STEARNS, LOUIS A., Box 155, Leesburg, Va. *Cercopidæ*, Cicadellidæ.
1921. STEVENS, O. A., Agricultural College, N. Dak. Bees and Wasps.
1923. STEWART, MORRIS ALBION, Tri Gamma House, Durham, N. H.
1914. STICKNEY, FENNER S., Indio, Calif. Coleoptera.
1915. STILES, CHARLES F., Box 37, Stillwater, Okla.
1922. STIRRETT, GEO. M., Purdue Univ., Lafayette, Ind. Halticini.
1913. STONER, DAYTON, 603 Summit St., Iowa City, Iowa. *Scutelleroidea*. Coleoptera.
1912. STRICKLAND, E. H., The University, Edmonton, Alberta.
1917. SULLIVAN, K. C., Horticulture Bldg., Columbia, Mo.
Ch. SUMMERS, H. E., 712 Edison St., Los Angeles, Calif.
1908. SUMMERS, JOHN N., 964 Main St., Melrose Highlands, Mass.
1921. SWEET, GEORGINA, The University, Melbourne, Australia. Arachnida, Insects.
1920. SWEZEY, OTTO H., H. S. P. A. Exp. Sta., Honolulu, Hawaii. Lepidoptera, Coleoptera, Homoptera.
1921. SWIFT, F. R., Corcoran Manor, Mt. Vernon, N. Y. Coleoptera, Diptera, Lepidoptera.
1922. SWINGLE, HOMER S., Sta. F, Columbus, Ohio. Homoptera.
1921. TAKAHASHI, RYOICHI, Dept. Agric., Govt. Research Inst., Taihoku, Formosa, Japan. Aphididæ.
1913. TALBERT, THOMAS JESSE, Whitten Hall, Columbia, Mo.
Ch. TANQUARY, M. C., Agric. Exp. Sta., College Station, Texas.

1922. Taylor, Leland H., Dept. Zoology, W. Va. Univ., Morgantown, W. Va. *Chrysididæ*, Vespoidea.
1922. Teranishi, Cho, No. 12, Nagi, Shirokita-mura, Higashinari-gun, Osaka, Japan. Scoliidæ, Formicidæ.
1921. Thomas, C. A., 120 Broad St., Kennett Square, Chester Co., Pa. Aphididæ, Hymenopterous parasites of same.
1915. Thomas, F. L., Box 24, Agric. Exp. Sta., Auburn, Ala.
1909. Thomas, W. A., Bur. Entom., Chadbourn, N. C.
1919. Thompson, Benj. G., 600 Twenty-sixth St., Sacramento, Calif.
1910. Thompson, W. R., European Parasite Lab., Le Mt., Fenouillet, Hyeres, Var. France. Parasitic Insects.
1922. Thornton, Clarence P., R. F. D. No. 2, Amherst, Mass.
1922. Tietz, Harrison M., 10326 118th St., Richmond Hill, L. I., New York. *Lepidoptera.*
1920. Tillyard, R. J., Cawthron Inst., Nelson, New Zealand. Odonata, Neuropteroids.
1911. Timberlake, P. H., H. S. P. A. Exp. Sta., Honolulu, Hawaii. *Encyrtidæ*, Syrphidæ, *Coccinellidæ.*
Ch. Titus, E. G., 215 S. 3rd East, Salt Lake City, Utah. Megachilidæ, *Osmiinæ.*
1913. Tothill, John D., Fredericton, N. B., Canada. Tachinidæ.
1921. Townsend, M. T., 301 N. H. Bldg., Urbana, Ill. Ecology.
1917. Treherne, R. C., Entom. Branch, Dept. Agric., Ottawa, Canada.
Ch. Troop, James, Purdue Univ., Lafayette, Ind.
1914. Tulloch, Bruce, Care of Messrs. Cox & Co., 16 Charing Cross, S. W., London.
1907. Turner, Charles H., Sumner High School, St. Louis, Mo.
1918. Turner, Wm. B., 600 26th St., Sacramento, Calif. Elateridæ.
1908. Turner, William F., Thomasville, Ga. Heteroptera.
1920. Uichanco, L. B., College of Agric., Los Banos Coll., Laguna, Philippine Islands. *Thysanoptera*, *Psyllidæ*, Aphididæ.
1917. Urich, F. W., 107 Frederick St., Port-of-Spain, Trinidad, British West Indies.
1922. Vance, Arlo M., U. S. Entom. Lab., Charlottesville, Va.
Ch. Van Dine, D. L., Box 113, State College, Pa.
1917. Van Duzee, Millard C., 12 Abbotsford Place, Buffalo, N. Y. Dolichopodidæ.
1918. Van Zwaluwenburg, R. H., Care of United Sugar Co's., Los Mochis, Sinaloa, Mexico. Elateridæ.
Ch. Vickery, R. A., 10 Court St., Arlington, Mass. Aphididæ.
Ch. Viereck, H. L., U. S. Biological Survey, Washington, D. C. Andrena, Odontophotopsis.
1913. Vorhies, Chas. T., University Sta., Tucson, Ariz.
1915. Wade, Joe S., Bur. Entom., Washington, D. C. Scarabaeidæ.
1921. Wadley, F. M., 126 S. Minneapolis Ave., Wichita, Kansas. Aphids, Hemiptera.
1918. Wainwright, Colbran J., Daylesfond, Handsworth Wood, Birmingham, England. *Tachinidæ.*

1922. WAKELAND, CLAUDE, Entomological Substation, Parma, Idaho.
1922. WALKDEN, HERBERT H., 126 S. Minneapolis Ave., Wichita, Kansas.
1917. WALLACE, FRANK N., State Entomologist, Indianapolis, Ind.
1911. WALLIS, J. B., School Board Office, Winnipeg, Canada. Coleoptera; *Haliplidæ, Gyrinidæ Agabus, Coelambus.*
1917. WALTON, W. R., Room 5, Bur. Entom., Washington, D. C. Cereal and Forage Insects.
Ch. WASHBURN, F. L., Exp. Sta., St. Anthony Park, Minn.
1913. WATSON, J. R., Agric. Exp. Sta., Gainesville, Fla. *Thysanoptera.*
1921. WATT, MORRIS N., St. John's Hill, Wanganui, New Zealand. Lepidoptera, Diptera, Hymenoptera.
1916. WEBBER, R. T., 17 E. Highland Ave., Melrose Highlands, Mass. Tachinidæ.
1920. WEBSTER, MILTON F., 121 Glenwood St., Malden, Mass.
Ch. WEBSTER, R. L., Agricultural College, N. Dak.
Ch. WEED, CLARENCE M., State Normal School, Lowell, Mass.
1917. WEESE, A. O., 1321 W. Wood St., Decatur, Ill. Ecology.
1918. WEHRLE, L. P., Renwick Heights, Ithaca, New York.
1917. WEIGEL, CHARLES A., U. S. Bur. Entom., Washington, D. C. Insects of Ornamentals.
1913. WEISS, HARRY B., 19 No. 7th Ave., Highland Park, New Brunswick, N. J. Buprestidæ.
1907. WELD, LEWIS H., U. S. Nat. Mus., Washington, D. C. *Cynipidæ.*
Ch. WELDON, GEO. P., Chaffey Jr. College Agric., Ontario, Calif. Thrips.
1921. WELLHOUSE, W. H., Agric. Coll., Ames, Iowa.
1919. WELLS, B. W., State College, Raleigh, N. C. *Insect Galls.*
1912. WELLS, M. M., 1177 E. 55th St., Chicago, Ill.
1920. WELLS, R. W., Box 208, Dallas, Texas. Insects affecting health of animals.
1920. WENDLER-FUNARO, KARL H., Cornell Univ., Ithaca, N. Y.
1921. WEST, LUTHER S., Dept. Entom., Cornell Univ., Ithaca, N. Y. *Tachinidæ,* Dexiidæ.
1918. WHEDON, ARTHUR D., 525 So. High St., West Chester, Pa. Odonata.
1922. WHEELER, GEORGE C., Dept. Zoology, Syracuse Univ., Syracuse, N. Y. Parasitic Hymenoptera, Ants.
1922. WHITEHEAD, FRED E., 1015 Bluemont Ave., Manhattan, Kansas.
1917. WILD, WILLIAM, 359 Walnut St., East Aurora, N. Y. Microlepidoptera.
1921. WILEY, GRACE OLIVE, 2291 Doswell Ave., St. Paul, Minn. *Nepidæ, Veliidæ. Hydrometridæ, Rheumatobates.*
1914. WILLIAMS, R. C., JR., 4537 Pine St., Philadelphia, Pa. Hesperidæ.
1917. WILLIAMS, S. H., State Normal School, Slippery Rock, Pa.
1911. WILLIAMSON, WARREN, R. F. D. No. 5, Galesburg, Ill.
Ch. WILLING, T. N., 417 Clearance Ave., Saskatoon, Saskatchewan, Canada.
Ch. WILSON, H. F., Univ. Wisc., Madison, Wisc.
Ch. WIRTNER, M., St. Bonifacius, Pa.
Ch. WOGLUM, R. S., 831 Consolidated Realty Bldg., Los Angeles, Calif.
1908. WOLCOTT, R. H., Univ. of Nebraska, Lincoln, Nebr.
1913. WOOD, H. P., Box 238, Dallas, Texas.

1914. Wood, W. B., Dept. Agric., Federal Horticultural Board, Washington, D. C.
1913. Woods, William C., Judd Hall, Middletown, Conn. Chrysomelidæ.
1917. Woodworth, C. W., Kiangsu Province, Shanghai, China.
1917. Woodworth, H. E., 2237 Carlton St., Berkeley, Calif. Thysanoptera.
1922. Worthley, Harlan N., Agric. Exp. Sta., Amherst, Mass. Tachinidæ.
Ch. Yothers, W. W., Box 491, Orlando, Fla.
1917. Yuasa, H., Care of Japanische Botschaft, Koningsplatz 4, Berlin, Deutschland. Sawfly larvæ.
1917. Zahrobsky, V. J., 287 Wood St., Wilmerding, Pa.
1921. Zerny, Hans, Wien I, Burgring 7, Austria. Heterocera.
1907. Zetek, James, Box 245, Ancon, Canal Zone. Injurious insects of Canal Zone and Panama.